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Measuring student engagement in technology-mediated learning: A review

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ABSTRACT

Using digital technology to deliver content, connect learners, and enable anytime, anywhere learning is increasing, but keeping students engaged in technology-mediated learning is challenging. Instructional practices that encourage greater engagement are essential if we are to effectively use digital instructional technologies. To determine the impact of innovative instructional practices on learning, we need useful measures of student engagement. These measures should be adaptable to the unique challenges to studying technology-mediated learning, such as when students learn at a distance or in a blended learning course. In this review, we examine existing approaches to measure engagement in technology-mediated learning. We identify strengths and limitations of existing measures and outline potential approaches to improve the measurement of student engagement. Our intent is to assist researchers, instructors, designers, and others in identifying effective methods to conceptualize and measure student engagement in technology-mediated learning.

1. Introduction

Technology-mediated learning experiences are becoming the norm for today's students. Numerous one-to-one tablet and laptop initiatives are promoted by schools and governments around the world (Clarke & Svanaes, 2014; Fuhrman, 2014; Tablet initiatives, 2014). The number of students taking online and blended courses continues to increase (Aud et al., 2012; Parsad & Lewis, 2008; Picciano, Seaman, Shea, & Swan, 2012; Staker et al., 2011; Watson, Pape, Murin, Gemin, & Vashaw, 2014). Grants worth thousands and millions of dollars have been awarded by federal and private institutions for research and development of intelligent tutoring systems, digital educational games, and other systems designed to personalize instruction and engage learners (e.g., D'Mello & Graesser, 2012; Goldsworthy, Barab, & Goldsworthy, 2000; Kafai, Tynes, & Richard, 2014; STEM Grand Challenge, 2012; Woolf, Arroyo, Cooper, Burleson, & Muldner, 2010).

Helping students engage in learning is an important issue for research in instructional technology. High dropout rates for online courses and MOOCs continue to be a challenge (Jordan, 2014; Patterson & McFadden, 2009; Rice, 2006; Roblyer, 2006). Tools are being developed to try to identify students who may be disengaging from instruction and are thus at risk of dropping out (Bienkowski, Feng, & Means, 2012; Long & Siemens, 2011). Other researchers have studied how innovative instructional practices impact student engagement in technology-mediated experiences (e.g., Chen, Lambert, & Guidry, 2010; Junco,

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Heiberger, & Loken, 2011; Liang & Sedig, 2010). Determining how to best use people and technology to engage learners in meaningful and effective learning experiences is an important endeavor for researchers today.

Research that improves the design of instruction needs good measures of student engagement to evaluate the efficacy of instructional interventions. Several publications review methods and identify issues that need to be addressed to improve the measurement of student engagement (Betts, 2012; Fredricks & McColskey, 2012; Fredricks et al., 2011; Samuelsen, 2012). These publications tend to focus on self-report measures of engagement, particularly quantitative scales. But yet to be addressed are ways that student engagement can be measured in relation to the methodological issues unique to technology-mediated learning experiences. For example, observational measures implemented in classrooms where all students are present in one location would be challenging to arrange for an online course in which students learn separately and at a distance. Additionally, technology affords us with new methods to measure student engagement in ways both scalable and minimally disruptive to learning, such as using computer-generated data of user activity with a learning system (Aleven, Mclaren, Roll, & Koedinger, 2006; Baker et al., 2012; D'Mello & Graesser, 2012). The purpose of this review is to examine approaches to measuring student engagement in technology-mediated learning experiences and to identify issues needing attention to improve the measurement of engagement in such settings.

1.1. Background

Student engagement has been defined as investment or commitment (Marks, 2000; Newmann, 1992; Tinto, 1975), participation (Kuh, Kinzie, Buckley, Bridges, & Hayek, 2007), or effortful involvement in learning (Astin, 1984; Pekrun & Linnenbrink-Garcia, 2012; Reschly & Christenson, 2012; Terenzini, Pascarella, & Lorang, 1982). Researchers have used various terms to define this idea, including *student engagement, academic engagement*, *school engagement*, and *learner engagement* (Reschly & Christenson, 2012). Some would argue that each of these terms takes on different nuances in definition. For example, learner engagement could be considered a broad term that includes learning both in and outside of formal academic settings, whereas student engagement would focus solely on academic learning. We use the term student engagement, as our interest is in academic learning.

Student engagement has been studied at the level of learning within a single activity, focusing on what is happening in the moment, to the level of a student's whole school experience. Skinner and Pitzer (2012) developed a model that best explains the levels at which student engagement has been studied, as well as the general outcomes of interest at those levels. At the broadest level is institutional engagement, which focuses on activity in social institutions in general, such as school, family, and church. Outcomes of this level of engagement are character development and pro-social orientation. Moving deeper, research can focus on engagement in all school-related activities, such as involvement in clubs, sports, or other student organizations and activities as well as academic work in the classroom. The outcomes of this engagement are a sense of belonging in school and lower risks of dropout. Engagement can then be focused on involvement in a specific course, or even on a specific learning activity, the outcome being academic achievement and learning. Skinner and Pitzer's framework of student engagement is useful for identifying the purpose and scope of various measures of engagement, from factors specific to a single learning activity to broader institutional concerns. For instance, the National Survey of Student Engagement (Kuh, 2001) is best suited for studying institution-level engagement, with questions focused on learners' general experience in school. Institution-level measures would be inadequate to identify insights as to how a specific learning activity affected learner engagement in a course.

Many researchers view student engagement as a meta-construct that includes different types of engagement or other theoretical constructs, such as motivation and self-regulation (Fredricks, Blumenfeld, & Paris, 2004; Reschly & Christenson, 2012). Fredricks et al. (2004) described what have become the common sub-constructs or types of engagement: behavioral, emotional, and cognitive engagement. According to Fredricks et al. (2004), behavioral engagement includes the observable behaviors necessary to academic success, such as attendance, participation, and homework completion. Emotional engagement includes both feelings learners have about their learning experience, such as interest, frustration, or boredom, and their social connection with others at school. Cognitive engagement is the focused effort learners give to effectively understand what is being taught, including self-regulation and metacognitive behaviors (Fredricks et al., 2004). Cognitive engagement and behavioral engagement center on actions by the learner. Cognitive engagement differs from behavioral engagement because it focuses on the less observable effort expended in the mind (Appleton, Christenson, Kim, & Reschly, 2006). As student engagement includes both self-perception and behavior, self-reported and observable indicators can be appropriate.

Research has linked behavioral, cognitive, and emotional engagement to important educational outcomes, such as student persistence in learning (Berger & Milem, 1999; Fredricks et al., 2004; Kuh et al., 2008), satisfaction (Filak & Sheldon, 2008; Zimmerman & Kitsantas, 1997), and academic achievement (Fredricks et al., 2004; Hughes, Luo, Kwok, & Loyd, 2008; Kuh et al., 2007; Ladd & Dinella, 2009). Despite these findings between academic outcomes and the various engagement constructs, comparing and confirming findings from different studies is difficult (Fredricks & McColskey, 2012; Janosz, 2012). The findings of two studies relating student engagement with positive outcomes may conflict due to differences in definition or construct conceptualization. The future success of research relating sub-constructs of engagement to specific outcomes relies on consensus of definitions and measures of engagement.

While student engagement is important in any learning context, our review focuses on student engagement in technology-mediated learning experiences: which includes any interaction of the learner with instructors, other students, or learning content through use of digital technology. This can happen face to face or at a distance, and the courses involved may be entirely online, blended, or face to face. When compared to traditional face-to-face learning experiences, these technology-mediated learning contexts pose unique measurement challenges. For example, learning that occurs at a distance is costly to observe and hard to scale. Additionally, technology-mediated learning experiences may provide meaningful student engagement data unavailable in more traditional contexts, as many of the systems used in technology-mediated learning keep records of summative and real-time data about student interactions with the system.

Fredricks et al. (2011) and Fredricks and McColskey (2012) identified methods to measure learner engagement in K-12 contexts. These methods involve surveying students or obtaining observations from teachers about student engagement. The instruments were designed not only to capture information on students' observable behaviors, such as participation or attendance, but to identify the less observable emotional, cognitive, and social experiences as well. One limitation to the measures examined in these reviews is that they were designed for, and in some cases can only be used in, face-to-face learning contexts. For example, a teacher report method would likely be ineffective for an online course for which teachers are not physically present to observe student behavior. Nor do the approaches reviewed address the challenges unique to measuring student engagement in technology-mediated learning experiences. As students learn more using technology and away from traditional brick and mortar locations, measures of engagement must be appropriate to these learning contexts. The purpose of this literature review is to explore how student engagement has been measured in technology-mediated learning experiences and to examine the strengths and limitations of those approaches.

2. Method

2.1. Overview

In this literature review, we sought to understand how student engagement has been measured in technology-mediated learning experiences. Our purpose was to learn what others have done to address challenges and opportunities unique to measuring student engagement in these contexts and to identify directions for improvement. To do so, we searched for literature on the subject from three major education and technology research databases. We then analyzed the resulting articles for the context in which student engagement was studied and the ways student engagement was defined and measured. Details of our method for conducting the literature review are described below.

2.2. Selection procedure

We patterned our search procedure after Fredricks et al. (2011). We used three databases offered through EBSCOhost to gather literature: Education Resources Information Center (ERIC), Education Full Text, and Computers and Applied Sciences Complete (CASC). ERIC and Education Full Text were chosen for their breadth in educational research. CASC, a database with good coverage in general technology research, was chosen to find technology-related research in education that might be classified outside of ERIC and Education Full Text.

Our most important search term was *engagement*. Student engagement has become a popular term in the literature with a large research base. Although closely related terms can be found, such as *involvement*, *participation*, or *affect,* we chose to focus solely on articles using the word *engagement*. We limited results to articles with the word *engagement* in the abstract, reasoning that a study focused on research in student engagement would be represented by an abstract including that term.

In addition to the search term *engagement*, we developed three other categories of search terms to narrow results to a manageable set: *technology*, *measurement*, and *school context*. *Technology* terms, such as *computer-assisted instruction* or *online learning*, were used to identify articles related to technology-mediated learning. *Measurement* terms, like *analysis* or *instrument*, were used to narrow results to articles conducting studies that actually measured student engagement. We employed a broad definition of measurement to include both quantitative and qualitative approaches. Researchers using qualitative approaches, while not assigning numbers to determine the degree of an attribute, still conceptualized student engagement and gathered data to study the construct. *School context* terms, including *elementary education* or *undergraduate students*, were used to narrow results to academic learning experiences, the area of focus for this study, rather than publications for corporate learning or informal learning. We began with a large list of possible terms for each of these categories by reviewing those used by Fredricks et al. (2011) and exploring the thesaurus feature provided by EBSCOhost, which indexes subject terms assigned to articles by the database. Thesaurus was specifically used for developing search terms for the technology and school context categories, as terms in these categories were specifically searched for in subject fields. All possible terms were paired individually in a search with *engagement* in all three databases. Any terms that did not yield results were dropped from the list. Final terms and search fields used in each of these categories are displayed in Table 1.

Our search began in February 2014 and concluded in December 2014. We limited results by publication type, choosing to review only scholarly journal publications. We believe this scope represents quality research publications within a reasonable breadth of the literature. Our final search resulted in a total of 407 unique articles. We then narrowed our initial collection of literature to sources truly relevant to the purposes of our study. We searched all abstracts for any indication that engagement had been measured, including phrases such as “produced higher engagement” (Neumann & Hood, 2009) or “effectively increased student engagement” (Beckem & Watkins, 2012). We also confirmed that the study was conducted in an academic

Table 1
Search terms.

Category	Terms	Search fields used
Engagement	Engagement	Abstract field
Technology	"blended learning," "computer assisted instruction," "computer managed instruction," "courseware," "distance education," "electronic learning," "integrated learning systems," "intelligent tutoring systems," "online courses," "mobile learning," "virtual classrooms," "web based instruction"	Subject field
Measurement	"analysis," "assess," "change," "correlation," "data analysis," increas*, "instrument," level*, measur*, "mixed methods research," "questionnaire," "regression," "scale," statistic*, "survey"	Title field Abstract field
School context	"elementary education," "elementary secondary education," "graduate students," "graduate study," "high school students," "high schools," "higher education," "intermediate grades," "junior high school students," "junior high schools," "middle school students," "primary education," "secondary education," "secondary school students," "undergraduate students," "undergraduate study"	Subject field

Note. Term format shows whether quotes were or were not used in the search.

context with a technology-mediated learning experience. If the abstract was unclear on any of these criteria, the article was coded as irrelevant. Following this process, we narrowed our review pool from 407 publications to 176.

2.3. Coding

Next we analyzed the remaining 176 publications to determine how research on student engagement in technology-mediated learning had been conducted. Articles were coded for relevancy and context, as well as for measures of engagement and types of engagement indicators used (see Tables 2–4 for category definitions). We restricted relevancy to those articles in which a measurement of engagement was described and the term *engagement* was used, not a synonym of the term such as *motivation* or *interest*. For example, McNaught, Lam, and Cheng (2012) used *engagement* in their article three times but did not discuss how student engagement was measured, even though the abstract described finding a relationship between student engagement and learning outcomes. Additionally, articles were excluded if students were not using digital technology to learn. For example, Coffey (2011) noted that simulations impacted student engagement; however, when we reviewed the article we found that the study was limited to face-to-face simulation activities that did not utilize digital technologies. We excluded 63 articles from our list because they did not explicitly measure student engagement or did not study a technology-mediated learning experience.

For the research context category, articles were coded for grade level, number of participants involved in the study, type of course involved, location of the learning experience, and technology used. For the engagement measures category, articles were coded for type of measure used and level of engagement measured using Skinner and Pitzer (2012) framework. For the engagement indicators category, researchers determined whether student engagement indicators identified by the article were behavioral, cognitive, or emotional, according to definitions taken from Fredricks et al., (2004).

Two researchers coded articles together to develop a system for coding and to establish consistency on ratings. Once a system was established, 20 percent of the articles were coded blindly by two researchers, whose coding results were then compared to determine inter-rater reliability as measured by Cohen's kappa. Three subcategories did not have a satisfactory kappa score: level of engagement ($k = 0.35$), behavioral indicators ($k = 0.00$), and cognitive indicators ($k = 0.39$). These subcategories were then subject to a second review using ten additional relevant articles for which one rater identified the paragraphs that contained information about those codes and the other rated only on those paragraphs. We did this so the

Table 2
Description of Research context coding Category.

Subcategory	Kappa	Code	Description
What was the grade level of participants?	$n = 19$	K6	Participants were in kindergarten to grade 6.
	$\boldsymbol{k} = \mathbf{0.867}$	7–12	Participants were in 7th to 12th grade.
	$Po = 0.895$	K12	Participants included both K6 and 7–12.
		HE-U	Participants were undergraduate students at a higher education institution.
		HE-G	Participants were graduate students at a higher education institution.
		HE	Participants included both undergraduate and graduate students.
In what location did the learning experience studied take place?	$n = 19$ $\boldsymbol{k} = \mathbf{0.833}$	Face to face	Learning occurred face to face in a school classroom, computer lab, or researcher's lab.
	$Po = 0.895$	Distance	Learning was mediated by technology with no face-to-face interaction with other learners or with the instructor as part of the learning experience.
		Both	Learning took place both face to face and at a distance.
		?	It was unclear where learning occurred.
In what type of course did the learning experience take place?	$n = 19$	Face to face	The course met face to face in a traditional brick and mortar location.
	$\boldsymbol{k} = \mathbf{0.778}$	Online	The course was labeled an online course in the article.
	$Po = 0.895$	Blended	The course was labeled a blended, hybrid, or mixed method course in the article.
		?	The course type was unclear.
How many participants were involved?	–	Open coded	The article identified the number of participants, number of courses or sections, and the number of institutions involved in the study.

Note. K is Kappa score, and Po is proportion of observed agreement.

Table 3
Description of engagement measures coding category.

Subcategory	Kappa	Code	Description
At what level was student engagement measured? (Based on Skinner & Pitzer, 2012)	$n = 10$ **$k = 0.756$** $Po = 0.900$	School	The measurement focused on the whole school experience, including activity both inside and outside the classroom.
		Course	The measurement focused on the whole classroom experience, including interactions of the learner with the learning content, other learners, and the instructor.
		Activity	The measurement focused on engagement in a learning activity or set of learning activities occurring within a course.
Were quantitative surveys used to measure engagement?	$n = 19$ **$k = 1.000$** $Po = 1.000$	Yes or no	Surveys with quantitative items were used, soliciting student or teacher perceptions concerning the presence or degree of particular indicators of engagement.
Were qualitative measures used to study engagement?	$n = 19$ **$k = 0.671$** $Po = 0.842$	Yes or no	Measures that assessed engagement qualitatively were used, often including interviews, open-ended survey questions, discourse analysis, or observation.
Were frequency measures used to study engagement?	$n = 19$ **$k = 0.678$** $Po = 0.842$	Yes or no	Observers obtained or kept track of frequency of behaviors, such as the number of assignments turned in or the amount of time spent on an assignment. This also included articles that obtained frequency scores for observations involving qualitative measures.
Were other measures used to study engagement? If so, describe.	$n = 19$ **$k = 1.000$** $Po = 1.000$	Yes or no	This category allowed for other categories of measures to emerge.
Was a named survey used or adapted to measure engagement? If so, what was the survey?	$n = 19$ **$k = 0.855$** $Po = 0.947$	Yes or no	The purpose of this item was to identify quality surveys used or repurposed to study student engagement.

Note. K is Kappa score, and Po is proportion of observed agreement.

raters were focused more on interpreting the same evidence. Many studies did not designate engagement indicators as being behavioral, cognitive, or emotional engagement, and it was difficult to find relevant evidence in the article. Having one researcher identify the evidence first and then having both researchers code allowed them to focus on agreement of definitions rather than on agreement on locating all possible evidence. Kappa results are included in Tables 2–4.

Coding in all categories but one yielded a satisfactory kappa score of 0.61 or higher, which Landis and Koch (1977) interpret as substantial agreement (see Tables 2–4). The code that did not get a score of 0.61 or more was cognitive engagement, under the engagement indicators category. The two researchers were able to achieve 0.60 on this subcategory, which is considered moderate agreement. Results of indicators of cognitive engagement should be interpreted with some caution. Any coding differences were discussed by the two researchers until agreement was achieved. The remaining articles were coded by researchers separately. Trends in codes were then analyzed, with meaningful patterns reported in the results section below.

2.4. High impact publications

The next step of our review was to determine the impact of research measuring student engagement, which we based on citation counts from Google Scholar citation metrics as of December 2014. Google Scholar is a useful resource for gathering citation counts because of its indexing breadth and capacity to give current results (Chen, 2010; Halverson, Graham, Spring, & Drysdale, 2012). We searched the title of each relevant publication in Google Scholar and recorded the number of times the publication had been cited according to Google Scholar metrics. We sorted our results by citation count and identified a list of the ten most cited publications overall, as well the five most cited publications of the last three years (2012–2014). We then reviewed these publications to highlight the contributions made.

3. Results

In this section, we review the results of our coding and review process. We first look at trends in the contexts in which student engagement was measured, followed by an analysis of ways engagement was defined and measured. We end with a description and analysis of the high impact articles as determined by the number of citations and a review of the contributions made by these studies.

3.1. Overall context

Much of the research we reviewed occurred in higher education contexts with undergraduate students. The largest category of research took place in face-to-face courses but focused on learning that occurred at a distance. Tables 5–7 contain

Table 4
Description of engagement indicators coding category.

Subcategory	Kappa	Code	Description
Did the measurement of engagement include *behavioral* indicators?	$n = 10$ $\boldsymbol{k} = \mathbf{1.000}$ $Po = 1.000$	Yes or no	"Across the various behavioral engagement scales/subscales, individual items ask students to report on their attention, attendance, time on homework, preparation for class, class participation, concentration, participation in school-based activities, effort, adherence to classroom rules, and risk behaviors" (Fredricks et al., 2004, p. 771).
Did the measurement of engagement include *cognitive* indicators?	$n = 10$ $\boldsymbol{k} = \mathbf{0.600}$ $Po = 0.800$	Yes or no	"Cognitive engagement is used as a broad umbrella term for (1) beliefs about the importance or value of schooling, learning goals, and future aspirations; (2) cognitive strategy use (how deeply students study material); (3) self-regulatory or meta-cognitive strategies (how students manage the learning processes such as planning and seeking information); and (4) doing extra work and going beyond the requirements of school. These measures of cognitive engagement incorporate aspects of motivation, self-regulated learning, and strategy use" (Fredricks et al., 2004, p. 772).
Did the measurement of engagement include *emotional* indicators?	$n = 19$ $\boldsymbol{k} = \mathbf{1.000}$ $Po = 1.000$	Yes or no	"Overall, emotional engagement scales include questions about a myriad of topics related to emotional reactions to school such as being happy or anxious; expressing interest and enjoyment; reporting fun and excitement; reacting to failure and challenge; feeling safe; having supportive or positive relationships with teachers and peers; having family support for learning; expressing feelings or belonging" (Fredricks et al., 2004, p. 772).

Note. K is Kappa score, and *Po* is proportion of observed agreement.

findings of the research context analysis. Studies had been conducted on a wide range of participant populations, with some studies focusing on only a small group of students in one or two courses, to large studies involving thousands and tens of thousands of students from multiple institutions (e.g., Chen, Gonyea, & Kuh, 2008; Chen et al., 2010; Han & Finkelstein, 2013). Student engagement was studied in a variety of technology-mediated learning experiences. Technology included clickers, virtual simulations such as Second Life, learning management systems, mobile applications, video lectures, and social communication technologies such as Twitter. The five most studied technologies were online discussion boards, general websites, learning management systems, general computer software, and videos.

Research we examined expressed several reasons for measuring student engagement, but by far the most prevalent was to evaluate whether a learning intervention using technology positively impacted student engagement. For example, Bolliger and Armier (2013) evaluated the impact of student-generated audio files on student engagement in a graduate-level course. Another example includes the study done by Lehman, Kauffman, White, Horn, and Bruning (2001) on the impact of different types of instructor email content on student engagement in an online course. Student engagement was also measured to understand its relationship with other theoretical constructs in technology-mediated learning experiences, such as confidence (Barkatsas, Kasimatis, & Gialamas, 2009; Giesbers, Rienties, Tempelaar, & Gijselaers, 2014; Pierce, Stacey, & Barkatsas, 2007), self-efficacy (Mills, Herron, & Cole, 2004; Spence & Usher, 2007; Sun & Rueda, 2012), and social presence (Liu, Magjuka, Bonk, & Lee, 2007; Wise, Chang, Duffy, & Valle, 2004).

3.2. How student engagement was defined

As discussed in the introduction, student engagement has been variously defined across the research with as much divergence as agreement. We were not surprised to find great variety in the ways that student engagement was defined and operationalized in these measurements. For example, Spence and Usher (2007) focused on *courseware engagement*, which they defined as "the degree of effort and persistence students report putting forth to use each of the four primary courseware features; these are the video tutor, tutorial practice problems, guided solutions, and sample tests" (p. 273). Blackwell, Fisher, Garcia, and Greene (1975) were interested in *task engagement* and sought to measure student behaviors in relation to the technological tool, such as focusing eyes on device or touching the keyboard. Bluemink and Järvelä (2004) studied *joint engagement*, which they defined as intensive group work to make decisions and solve problems or tasks. Such engagement,

Table 5
Types of courses in which student engagement was studied.

Type of course	Frequency	Percent
Face-to-face course	54	47.8%
Online or distance course	23	20.4%
Blended course	11	9.7%
Course type uncertain	12	10.6%
Combination of courses	13	11.5%
Total	113	100%

Table 6
Level of students studied.

Type of course	Frequency	Percent
Grades K-6	9	8.0%
Grades 7–12	15	13.3%
Both K-6 and 7–12	9	8.0%
Undergraduate students	47	41.6%
Graduate students	14	12.4%
Both undergraduate and graduate	19	16.8%
Total	113	100%

the authors contended, "requires continuous attention to grasp the ideas of the participants and to interpret meanings" (p. 203). Other studies looked at student engagement more broadly, but broke the construct into sub-constructs, as will be discussed shortly.

Although we expected the terms to be defined and operationalized differently, we were surprised to find that most of the reviewed articles did not have clear definition statements for engagement. Student engagement was linked to motivation, participation, academic achievement, and interaction with classmates or instructors (among other factors); it was operationalized as time spent on a webpage or with eyes on a screen or as attendance in a face-to-face class. However, these were operationalizations; clear definitions were scarce. One article with a clear definition statement of engagement was by Yang (2011), who borrowed from Cole and Chan (1994, p. 259): "Students' engagement is defined as 'the extent of students' involvement and active participation in learning activities'" (p. 182). Nakamaru (2012) also clearly defined student engagement but used the words of Greene, Marti, and McClenney (2008, p. 514): "I adopt the definition of engagement as 'the effort, both in time and energy, students commit to educationally purposeful activities'" (p. 275). Järvelä, Veermans, and Leinonen (2008) included their own working definition of engagement as "student psychological investment in learning in terms of motivational interpretations and goals as described in achievement goal theory" (p. 302). Sun and Rueda (2012) likewise had a clear and singular statement of definition: "In academic settings, engagement refers to the quality of effort students make to perform well and achieve desired outcomes" (p. 193). We found it troubling that the majority of articles reviewed included no statement expressing the researchers' definition of student engagement. If research on this topic is to gain theoretical cohesiveness, definitional clarity about engagement and its sub-constructs is critical.

When authors did not define engagement, we focused on ways they operationalized engagement, since doing so was a necessary step to measuring various indicators of engagement. Skinner, Furrer, Marchand, and Kindermann (2008) explained that the term *indicators* "refer[s] to the features that belong inside the construct of engagement proper" (p. 766), such as excitement, interest, or attention. In contrast, *facilitators* of engagement, or "the causal factors (outside of the construct) that are hypothesized to influence engagement" (p. 766), include variables such as motivation or self-efficacy. As we were interested in how engagement has been measured in technology-mediated environments, we paid close attention to how each article operationalized and measured chosen engagement indicators.

Occasionally within the same article engagement was defined in one way but operationalized and measured in another. For example, Cocea and Weibelzahl (2011) related engagement to constructs such as interest, effort, focus of attention, and motivation, and then defined it as "the entire mental activity (involving at the same time perception, attention, reasoning, volition, and emotions)" (p. 115). However, measures of engagement in this article were more narrowly behavioral, including the time spent on reading online pages and the number read, as well as the time spent, pages read, and correct/incorrect responses on online tests.

A few articles construed engagement through its opposite, by operationalizing and measuring disengagement, primarily through off-task behaviors, disruptions, or inactivity (Donovan, Green, & Hartley, 2010; Hayden, Ouyang, & Scinski, 2011; Rowe, Shores, Mott, Lester, & Carolina, 2011). Yet some research has argued that disengagement or disaffection is not merely the bipolar opposite of engagement, but its own unipolar construct (Skinner, Kindermann, & Furrer, 2009). Construct validity of student engagement can be improved through clarity of construct and sub-construct definitions.

As stated in the Methods section, we determined whether the student engagement indicators identified by the article were behavioral, cognitive, or emotional engagement indicators, as defined in Fredricks et al., (2004). We chose these categories as they are widely used; however we found a variety of other engagement sub-constructs in the literature we reviewed. For example, Dixson (2010) and Mandernach (2009) applied constructs from Handelsman, Briggs, Sullivan, and Towler's (2005) Student Course Engagement Questionnaire (SCEQ): skills engagement, emotional engagement, participation/interaction engagement, and performance engagement. Bangert-Drowns and Pyke (2002), Lim, Nonis, and Hedberg (2006), and Lim (2008) all used a seven-level taxonomy of engagement ranging from disengagement and unsystematic engagement through critical engagement and literate thinking (Bangert-Drowns & Pyke, 2001). Such examples highlight the amorphous and evolving nature of the construct and the importance of providing clear construct definitions.

Very few of the articles expressly labeled their indicators of engagement using the sub-constructs identified by Fredricks et al., (2004); even articles that discussed behavioral, cognitive, and emotional types of engagement did not identify different indictors of the sub-constructs. However, Yang (2011) not only reviewed the three sub-constructs of engagement but suggested ways to measure them broadly in computer-mediated settings and specifically linked various measurements to each category. Because Yang's development was the exception, we usually had to make subjective decisions in categorizing the

Table 7
Location of student learning.

Type of course	Frequency	Percent
Face to face	39	34.5%
At a distance	47	41.6%
Both F2F and at a distance	19	16.8%
Learning location uncertain	8	7.1%
Total	113	100%

indicators. Table 8 shows the range of indicators utilized to measure engagement and our categorization of them using Fredricks' et al., (2004) descriptions. We were frustrated by the lack of clarity in definitions and operationalization, which makes it difficult to understand reasons for the differences in research on student engagement.

Of the 113 articles we reviewed, 77% operationalized engagement from a behavioral perspective, with indicators that included participation, attendance, assignments completed, time logged in, and other on-task behaviors. In technology-mediated learning settings, behavioral engagement can potentially be measured by computer-recorded indicators such as assignments completed; frequency of logins to website; number and frequency of postings, responses, and views; number of podcasts, screencasts, or other website resources accessed; time spent creating a post; and time spent online.

Cognitive engagement indicators were utilized in 43.4% of the articles we reviewed ($n = 113$). Cognitive engagement, involving beliefs, values, cognitive strategy use, and planning, may not always be externally visible and may require self-reporting. Some qualitative measures attempted to gauge when cognitive processes such as reflection, interpretation, synthesis, or elaboration were shown in student-created artifacts. At times the line between cognitive and behavioral engagement became blurred. For example, Kong (2011) was interested in the effect that a cognitive tool would have on classroom dialog, but operationalized engagement using an indicator of behavior (time on task). Zhu (2006) created a detailed framework for cognitive engagement in discussion boards, but the lowest levels (a direct response, for example) overlap with

Table 8
Ways engagement was operationalized.

Indicator category	Examples of how operationalized		Example sources
Behavioral	• Answers to recall questions • Assignments completed • Attendance in face-to-face class • Attention • Effort • Eyes on device; fingers on keyboard • Frequency of logins to website • Involvement with learning object • Number of postings, responses, & hits • Number, quality, & frequency of online posts & views • Number of podcasts used	• Off-task behaviors (inactivity, disruption, loitering too long on non-learning websites) • On-task behavior • Participation • Percentage of sessions with posting actions, views that were reads (not scans), & posts viewed at least once • Persistence • Questions asked publicly in class or online • Task engagement • Time-locked eye tracking • Time spent creating a post • Time spent online • Use or non-use of website resources, of screencasts	• Boucheix et al. (2013) • Peters et al. (2011) • Thompson et al. (2012)
Cognitive	• Analysis, synthesis, decision-making • Challenge • Cognitive attachment (represented by the *behavioral* indicator of on-task behavior) • Critical engagement • Elaboration • Explanation • Focus • Higher mental functions on Bloom's Revised Taxonomy	• Improved understanding • Internal dialog • Interpretation • Literate thinking • Perceived relevance • Perceived value • Problem-solving behavior • Psychological investment in learning • Reflection • Self-regulated interest	• Bangert-Drowns and Pyke (2002) • Guertin, Zappe, and Kim (2007) • Zhu (2006)
Emotional	• Anxiety • Boredom • Cheering (that it was a "laptop day") • Collaborative social interaction • Enjoyment • Enthusiasm • Excitement • Fun	• Happiness • Interest • Passion • Sense of class community • Student–student interactions • Visible expressions of pleasure • Expressed desire to use the tool again	• Kay (2011) • Missett et al. (2010) • Sun and Rueda (2012)

behavioral engagement indicators. Clearly more work is needed to distinguish these two types of engagement and to understand how each uniquely contributes to important learning outcomes.

Emotional engagement indicators included positive or negative emotions towards learning, classmates, or instructors, as well as social interactions and a sense of community. Like cognitive engagement, emotional engagement may include self-reporting but can sometimes be seen through visible expressions of positive emotion (Bebell & Kay, 2010; Wang, 2010). Emotional engagement indicators were present in 40.7% of the 113 articles surveyed, but they were more frequently studied in the K12 context: 63.6% of K12 studies ($n = 21$) measured student engagement with emotional indicators, while only 31.3% of the higher education studies ($n = 25$) did so. We found it interesting that emotional engagement is considered important to measure at the K12 level but loses stature to researchers as students mature. Yet emotions do not cease to be critical to learning as the learner enters the university. Pekrun (2011) has argued that emotions can influence "a broad variety of cognitive processes that contribute to learning, such as perception, attention, memory, decision making, and cognitive problem solving" (p. 26). And Skinner and Pitzer (2012) made an emphatic analogy: "Emotion is likely the fuel for the kind of behavioral and cognitive engagement that leads to high-quality learning" (p. 33).

Of the 113 articles reviewed, 43 percent measured engagement along only one indicator category. However, some articles measured more than one engagement category, and more than 21% included behavioral, cognitive, and emotional indicators. Some scholars have argued that the term engagement should be used only for work including multiple components (Fredricks et al., 2004; Guthrie & Wigfield, 2000) to ensure that the richness of real human experience is understood. Thus measuring engagement across more than one indicator may produce the most productive information for researchers, instructional designers, and educators.

3.3. How student engagement was measured

Student engagement in technology-mediated learning experiences was measured in various ways, ranging from self-report surveys and interviews to assessment scores and behavior counts. Of the 113 articles we reviewed, 60.2% of the studies relied on one method of measurement, but many utilized multiple measures (39.8%). Table 9 details the types and frequency of measures used. The following sub-sections review the major methods for measuring student engagement and the types of questions that can be answered about engagement using those measures.

3.3.1. Quantitative self-report

Surveys that use quantitative items (e.g., Likert scale) were commonly used for measuring student engagement in technology-mediated and blended learning (see Table 9). Some surveys contained only one or two items related to engagement, while others contained full scales with over a dozen engagement-related items. Survey items ranged from asking students how they would rate their perceived level of engagement (Gallini & Barron, 2001) to survey questions that addressed behavioral, cognitive, and emotional aspects of engagement (e.g., Chen et al., 2010; Price, Richardson, & Jelfs, 2007; Yang, 2011). Most surveys were completed by students, though some were used to collect perceptions of engagement from teachers (e.g., Gallini & Barron, 2001; Kay, 2011). Fourteen named surveys were used or adapted to measure student engagement, most of which were evaluated for their psychometric properties. Table 10 provides information about these named instruments.

The most frequently used named survey was the National Survey of Student Engagement (NSSE) developed by Indiana University (see Kuh, 2001). This institution-level survey is used to assess the quality of a students' college experience. Students are asked to report on their participation in activities shown to lead to engagement and quality educational experience, such as participation in collaborative projects, involvement in extracurricular activities, and level of preparation for class. The NSSE, often used to evaluate and compare institutions, was used in the studies we reviewed to compare the impact of different instructional interventions or modalities on student engagement. The majority of these comparisons were of face-

Table 9
Distribution of engagement measures used.

Measures	Description	Frequency
Quantitative self-report	Surveys, scales, or questionnaires with quantitative items soliciting student or teacher perceptions of the presence or degree of particular indicators of engagement	61.1%
Qualitative measures	Measures that assessed engagement qualitatively, often through interviews, open-ended survey questions, discourse analysis, or observation	39.8%
Quantitative observational measures	Frequency of behaviors observed or monitored, including number of assignments turned in or amount of time spent on an assignment, as well as frequency scores for observations obtained through qualitative measures	34.5%
Other	Other methods used to measure engagement, including performance and bio-physiological sensors reported as alternative methods to measure engagement	11.5%

Table 10
Named surveys used to measure Student engagement.

Name of instrument	Authored by	Internal consistency (Cronbach's alpha)	Methods used to assess construct validity	Types of indicators (B = behavioral C = cognitive E = emotional)
Academic Engagement Form	Richardson, Long, & Foster, 2004	0.56–0.70	Principal components analysis and factor analysis	B C E
Classroom Survey of Student Engagement	Ouimet & Smallwood, 2005	–	–	B C E
Classroom Engagement Survey	See Guertin, Zappe, & Kim, 2007	–	–	C E
Engagement Scale	Fredricks et al., 2005	0.67–0.86	Exploratory factor analysis	B C E
Learning Object Evaluation Scale	Kay & Knaack, 2007, 2009	0.63–0.89	Principal components factor analysis	C E
Mathematics & Technology Attitude Scale	Pierce et al., 2007	0.65–0.92	Principal components and exploratory factor analysis	B C E
National Survey of Student Engagement	Indiana University; Kuh, 2001	0.84–0.90	Principal components analysis	B C E
Online Student Engagement Scale	Dixson, 2010	0.91	Exploratory factor analysis	B C E
Perceived Interest Questionnaire	Schraw, 1997	0.92	Principal factor analysis	E
Positive and Negative Affect Schedule	Watson, Clark, & Tellegen, 1988	0.84–0.90	Principal factor analysis	E
Presence Questionnaire	Witmer & Singer, 1998	0.88	Cluster analysis	B
Short Flow State and Core Flow State Scales	Jackson & Eklund, 2004	0.80	Confirmatory factor analysis	B C E
Student Assessment of Learning Gains	Lim, Hosack, & Vogt, 2012	0.69–0.96	–	–
Student Course Engagement Questionnaire	Handelsman et al., 2005	0.76–0.82	Exploratory factor analysis	B C E
Student Engagement Questionnaire	Coates, 2006	0.59–0.81	Congeneric measurement modeling	B C E
Virtual Course Flow Measure	Shin, 2006	0.63–0.88	Principal components analysis	B

to-face and online courses (Chen et al., 2008; Chen et al., 2010; Rabe-Hemp, Woollen, & Humiston, 2009; Robinson & Hullinger, 2008). One study used a portion of the NSSE to compare student engagement in classes when Twitter was used and in classes where it was not (Junco et al., 2011), while another study looked at the impact of wikis on student engagement (Neumann & Hood, 2009). These studies highlighted engagement as a desirable outcome and examined ways instructional interventions, both large and small, impact student engagement.

Surveys are useful for investigating unobservable aspects of student engagement, particularly for understanding the emotions students experience or the mental energy or cognitive strategies they apply to learning (Appleton et al., 2006; Fredricks & McColskey, 2012). Surveys are a scalable option when students are learning at a distance, especially when compared to methods such as human observation. Surveys, however, are not always the best method for measuring student engagement. Surveys can be inappropriate for younger children, who may not understand the questions being asked. Further, timely data on student engagement are difficult to obtain via surveys. As midcourse or end-of-term self-report surveys are often lengthy, they require an inconvenient amount of time for students to complete. Moreover, the data are obtained at the end of the course or learning activity, not in the midst of it. Although this post hoc data can be used to improve future iterations of an instructional design, such data frequently have little benefit for the current students being observed. This is particularly relevant to those interested in developing systems that provide instructors and administrators feedback on student engagement in a course.

Variance in student engagement across time is also difficult to capture through surveys. Short surveys repeated periodically, such as the experience sampling method approach used to measure flow as detailed by Hektner, Schmidt, and Csíkszentmihályi (2007), is one way to capture variance in student engagement across time. However, such approaches tend to require significant effort from students completing them. Finally, surveys divert students from learning and may disrupt the very engagement we hope to measure. This problem is particularly intrusive when measuring student engagement at the activity level. More indirect measures, such as observational methods, could allow for measurement and uninterrupted learner engagement to occur simultaneously. These more indirect measures are described later in this article.

3.3.2. *Qualitative measures*

The second most frequent approach to measuring student engagement we observed was qualitative measures, which were used in 39.8% of the 113 studies we reviewed. These methods included direct, video, or screen capture observations of students' behavior while learning (Bluemink & Järvelä, 2004; Figg & Jamani, 2011; Rieth, Bahr, Polsgrove, Okolo, & Eckert, 1987); interviews or focus groups (Martin, Birks, & Hunt, 2009; Missett, Reed, Scott, Callahan, & Slade, 2010); and analysis of discussion boards or other digital communication tools (Giesbers et al., 2014; Granberg, 2010; Sutherland, Howard, & Markauskaite, 2010), where types of behaviors and written or verbal communication were categorized using preexisting frameworks and taxonomies (e.g., Laakso, Myller, & Korhonen, 2009; Lim, 2008; Rieth et al., 1987) or by identifying themes.

Qualitative measures are particularly useful for exploratory studies characterized by uncertainty concerning how to measure or define student engagement. For example, Paulus, Horvitz, and Shi (2006) analyzed text from an asynchronous discussion board, students' written reflections, and students' responses in interviews to explore what engagement was like when graduate students learned from stories in an online environment. Rather than defining the nature of student engagement a priori to develop a survey, the authors used qualitative measures that enabled them to approach engagement inductively. One challenge with using qualitative methods, however, is that they are difficult to scale. Extensive resources may be needed to collect data. It is often necessary to analyze data manually, limiting the amount of data researchers choose to examine. Many of the studies we reviewed were able to use these methods only with small numbers of participants.

3.3.3. *Quantitative observational measures*

Researchers used a variety of frequency-type indicators to observe the level of students' engagement in learning. These indicators were obtained using direct human observation, video recording, and computer-generated user-activity data. Frequencies tracked included the number of posts to a discussion board (Giesbers et al., 2014; Peters, Shmerling, & Karren, 2011; Xu, 2010), time on task (Kong, 2011; Laakso et al., 2009; Lehman et al., 2001), attendance (Heafner & Friedman, 2008), assignment completion (Gleason, 2012; Madyarov, 2009; Thompson, Klass, & Fulk, 2012), number of on-task or off-task behaviors (Blackwell et al., 1975; Donovan et al., 2010; Hayden et al., 2011), number of edits made during a writing task or discussion board activity (Nakamaru, 2012; Wise, Speer, Marbouti, & Hsiao, 2012), or number of page views in an online resource (Cocea & Weibelzahl, 2011; Morris, Finnegan, & Wu, 2005; Stewart, Stott, & Nuttall, 2011).

Observational methods, which include both frequency measures and some qualitative measures, such as discourse analysis, have the advantage of enabling researchers to measure student engagement as it occurs, rather than disrupting it or measuring it afterward as required with surveys. Observational measures tend to focus on engagement at the activity level, which is useful for researchers interested in studying engagement within an activity or a small moment of time. While surveys can also be tailored to investigate student engagement at the activity level, observational measures tend to have the advantage of less learning disruption. Qualitative measures are effective for describing the nature of engagement, but frequency measures can be useful for tracking how a certain quality of engagement changes over time or how degrees of engagement vary among individuals or groups.

Frequency measures of student engagement may limit the aspects of engagement that can be studied. Some researchers have defined student engagement as energy in action (Russell, Ainley, & Frydenberg, 2005). Observational frequency measures, usually records of manifested behaviors, are a logical means for studying energy in action. Student engagement, however, also includes emotional and cognitive aspects. Research suggests that these other aspects of engagement have unique relationships with other learning outcomes of interest (Fredricks et al., 2004). Appleton et al., (2006) argue that the most valid measure of cognitive and emotional engagement is self-report as these aspects of engagement focus heavily on students' perceptions of their experience (see also Fredricks & McColskey, 2012). Additionally, frequency measures of behavioral engagement may not by themselves provide an adequate understanding of the quality of engagement (Appleton, Christenson, & Furlong, 2008). Henrie, Bodily, Manwaring, and Graham (2015) found that the amount of effort needed to succeed in an online class as measured by student activity in the learning management system varied from student to student, making it difficult to determine *how much* engagement is needed for quality academic performance. Careful consideration is needed to determine which measures of student engagement are most appropriate when studying the relationship between student engagement and other variables, like academic performance.

Another limitation of observational measures of student engagement is the cost required to obtain the measure. Trained observers are often used to gather data in person, which can be particularly challenging when learning occurs at a distance and with learners in varied locations. While this may be the case when human observers are required to obtain the frequency measure, using computer-recorded frequency measures presents a more scalable and cost-effective option to study student engagement. Some systems provide reports of user activity, eliminating the need for manual counting. From our review we identified 10 articles that used computer-generated data to obtain frequency measures. These data included discussion board activity, assignment submissions, pages viewed, time spent on an activity, and other types of behaviors recorded by the system. In studying student engagement in technology-mediated learning, computer or system-generated frequency data should be considered if observational measures of student engagement are desired. We were surprised that data of this type were not used in more of the studies we reviewed, as most technology systems are capable of tracking user activity. More research using computer-generated data should be done to better understand its value for studying student engagement.

3.3.4. *Other methods for measuring student engagement*

We tracked additional methods for measuring engagement that did not fit in the major categories of survey, qualitative methods, and frequency. Ten studies used performance as an indicator of engagement, arguing that high student performance or high completion rates provided evidence of student engagement (e.g., Liang & Sedig, 2010; Rowe et al., 2011; Schilling, 2009). Student academic performance has been shown to correlate with student engagement, and where student engagement can be used to predict performance, certainly performance could act as an indirect measure of engagement. But one must consider information that is lost when using this indirect measure. Some students may perform well but be disinterested or frustrated rather than excited, interested, and engaged. Students' positive emotional responses to learning may be important immediate outcomes to achieve, but they also affect long-term persistence (see Fredericks et al., 2004).

Another type of measure of student engagement we observed used physiological sensors, which detect students' physical responses while learning. Boucheix, Lowe, Putri, and Groff (2013) used eye-tracking technology to determine the impact of different types of animation on student engagement and learning. Shen, Wang, and Shen (2009) used skin conductance, blood pressure, and EEG sensors to measure a student's emotional engagement while learning from interactive electronic lectures. Self-report data were provided by the student while this emotional monitoring occurred. Using the self-report data, a model was trained from the physiological data to be able to predict emotional states in future data without the need of collecting self-report. The model correctly identified learning emotions 86.3% of the time.

Physiological sensors provide a potential window into students' cognitive and emotional activity. Determining emotional or cognitive states from physiological sensors, such as heart rate, may be too speculative without confirming findings with self-report data, such as what was done by Shen et al., (2009). However, if physiological data can accurately correlate with responses from self-report, then engagement can be measured without having to disrupt students from learning. The challenge with using physiological sensors is the complexity of the technology as well as the cost. The student observed by Shen et al., (2009) had to be careful about placement of sensors and was physically restricted during monitoring. However, physiological sensor technology is improving with simple and more cost-effective options, making this type of measure more feasible for studying student engagement (D'Mello & Graesser, 2012).

3.4. High impact analysis

Our last analysis was to determine which articles from our literature review were most frequently cited in other scholarly work. We identified the five most cited articles overall as well as the five most cited articles between 2012 and 2014. Because there was a tie for 5th place among the most cited overall, six articles are included. The references can guide researchers to publications most cited in scholarly work on student engagement in technology-mediated learning. A wide range of technology-mediated learning experiences are represented. Tables 11 and 12 identify the results of this analysis, listing bibliographic information for each article as well as total citation count.

The highest cited article overall was by Junco et al., (2011). Two college course types were studied: one that used Twitter for educational purposes and one that did not. Researchers measured students' engagement in both course types using items from the National Survey of Student Engagement. Students who took classes using Twitter were found to have a statistically significant higher degree of engagement [$F(1, 4.9) = 12.12$, $p = 0.018$]. Students from both course types had a similar level of engagement before Twitter was used.

The highest cited article since 2012 was Sun and Rueda (2012). Researchers in this study investigated the relationship of student engagement, situational interest, self-efficacy, and self-regulation for undergraduate and graduate students in blended and online courses. Researchers used an adapted version of the Engagement Scale developed by Fredricks, Blumenfeld, Friedel, and Paris (2005) that measures behavioral, cognitive, and emotional engagement. They found strong relationships between student engagement and situational interest and self-regulation. They also found that online activities may be a means of increasing students' emotional engagement.

4. Discussion

The purpose of this review was to better understand how student engagement has been measured in technology-mediated learning experiences and to evaluate the potential of these measures. Table 13 provides a summary of the strengths and limitations of the measures we reviewed. We do not feel that any particular measurement method is the best

Table 11
Top five high impact articles as determined by total citation counts as of December 2014.

# of citations	Authors	Title	*Journal*
406	Junco et al., 2011	The Effect of Twitter on College Student Engagement and Grades.	*Journal of Computer Assisted Learning*
193	Conrad, 2010	Engagement, Excitement, Anxiety, and Fear: Learners' Experiences of Starting an Online Course	*The American Journal of Distance Education*
160	Zhu, 2006	Interaction and Cognitive Engagement: An Analysis of Four Asynchronous Online Discussions	*Instructional Science*
145	Lim et al., 2006	Gaming in a 3D Multiuser Virtual Environment: Engaging Students in Science lessons	*British Journal of Educational Technology*
140	Chen et al., 2010	Engaging Online Learners: The Impact of Web-Based Learning Technology on College Student Engagement	*Computers & Education*
140	Bebell & Kay, 2010	One to One Computing: A Summary of the Quantitative Results from the Berkshire Wireless Learning Initiative	*The Journal of Technology, Learning, and Assessment*

Table 12
Top five high impact articles as determined by total citation counts over years 2012–2014.

# of citations	Authors	Title	Journal
37	Sun & Rueda, 2012	Situational Interest, Computer Self-Efficacy and Self-Regulation: Their Impact on Student Engagement in Distance Education	*British Journal of Educational Technology*
30	Blasco-Arcas, Buil, Hernández-Ortega, & Sese, 2013	Using Clickers in Class. The Role of Interactivity, Active Collaborative Learning and Engagement in Learning Performance	*Computers & Education*
18	Owston, York, & Murtha, 2013	Student Perceptions and Achievement in a University Blended Learning Strategic Initiative	*The Internet & Higher Education*
14	Wise et al., 2012	Broadening the Notion of Participation in Online Discussions: Examining Patterns in Learners' Online Listening Behaviors	*Instructional Science*
12	Han & Finkelstein, 2013	Understanding the Effects of Professors' Pedagogical Development with Clicker Assessment and Feedback Technologies and the Impact on Students' Engagement and Learning in Higher Education	*Computers & Education*

for all situations. Each approach has its own strengths and limitations that should be carefully considered by those interested in measuring student engagement in technology mediated learning.

We found that quantitative self-report, particularly surveys, was the most common measure of student engagement in technology-mediated learning experiences. Surveys are a scalable measure of student engagement. Electronic survey administration systems, such as Qualtrics, Google Forms, and Survey Monkey, make it easier to distribute surveys to students who are learning at a distance. Additionally, surveys may be the most effective means of studying the psychological and cognitive aspects of student engagement. However, surveys are not the only measurement option for studying student engagement. Observational measures can capture student engagement as it is occurring, with less interference with learning. Additionally, if student engagement is defined as applied energy (Russell et al., 2005), it makes sense to use observational techniques to obtain evidence of that applied energy.

Traditional observation measures, using human observers and coders to obtain data, can be costly to administer and to prepare observers. However, other sources of frequency data are available for studying students using technology to learn. This data comes in the form of log data, or system reports of user activity. Log data are potentially useful for measuring student engagement in technology-mediated learning (Baker et al., 2012). Systems can be designed to automatically track and report on user activity, providing ready-made frequency data. The measure is unobtrusive, capturing data behind the scenes as students learn. Systems are also capable of providing granular student engagement data at the real-time level, which may be difficult for human observers to obtain, such as the number of clicks, the speed of mouse movement, and the time activity occurred. More research is needed to better understand what log data can tell us about the cognitive and emotional experience students are having as they learn. This research will likely need to follow Shen et al., (2009) example of comparing new approaches to established measures of cognitive and emotional engagement.

While we did not see as much research as we expected using log data to measure student engagement, we are aware of studies using log data to examine student learning (e.g., Arroyo, Murray, Woolf, & Beal, 2004; D'Mello, Picard, & Graesser,

Table 13
Summary of strengths and limitations of engagement measures.

Measure	Strengths	Limitations
Quantitative self-report	• Easy to distribute • Usable in F2F and distance learning • Useful for self-perception and other less observable engagement indicators • Effective for studies of student engagement at the course and institution levels	• May be too difficult for young children to complete • May be tedious if frequent repeated measures are necessary • Cannot be used to observe engagement in action unobtrusively
Qualitative measures	• Useful for exploratory studies of student engagement • Can be applied to less observable aspects with self-report • Can enable data gathering without disrupting learning • Effective for studies of student engagement at the activity level	• Costly and challenging to train human observers • Difficult to scale • Difficult to do when students learn at a distance
Quantitative observational measures	• Appropriate measure when defining engagement as energy in action • Effective for studies of student engagement at the activity level • Abundant data through systems • Less disruption to learning during data gathering	• May not adequately measure cognitive and emotional engagement • Costly, challenging, and difficult to scale if human observers gather data
Physiological sensors	• Effective for studies of student engagement at the activity level • Possible to use existing technologies to obtain data (i.e. webcams and track pads) • Potential approach to measuring cognitive and emotional engagement	• Difficult to scale because of cost • Needs further research to determine type of engagement information that can be obtained • Requires specialized training to use instruments and interpret data

2007; Gobert, Baker, & Wixon, 2015; Woolf et al., 2009). For example, Baker et al. (2012) used human observers to code students' affective states while learning with an intelligent tutoring system. Affective states observed included boredom, confusion, frustration, and engaged concentration. Data mining algorithms were then used to search for patterns in the log data from the intelligent tutoring systems that corresponded with the assessment of the human observers. The resulting models were then used to predict students' affect states from log data. These predictions were then compared to affective ratings from human observers. The prediction models were aligned with human observer ratings 70–99% of the time, depending on the affective state predicted and model used.

Other studies using log data to study student learning employed different terminology for constructs related to student engagement, such as *affect* or *involvement*. Our literature review focused only on those studies that used the term *engagement* as there was a significant amount of research to review using this term. But this review decision eliminated similar research, such as Baker et al. (2012) and others (e.g., Arroyo et al., 2004; D'Mello et al., 2007; Woolf et al., 2009). We may have also missed some studies on log data and student engagement because research in educational data mining and learning analytics is relatively new and found mostly in conference proceedings, which are generally not cataloged by the databases we used for this literature review. Future review work might look into these other sources of literature to identify trends and strengths in measures of student engagement in technology-mediated learning.

Perhaps the greatest challenge to the work of measuring and studying student engagement in technology-mediated learning, as well as the study of student engagement in general, is a lack of cohesion around definitions, models, and operationalization of student engagement. While this is expected with a relatively new construct (Fredricks & McColskey, 2012) with theoretical understanding still in development, it is difficult to identify what facilitates student engagement and how student engagement promotes other educational outcomes without clear definitions and shared measurements. This weakness is particularly challenging when studying sub-constructs of student engagement. As noted in this review and elsewhere (Reschly & Christenson, 2012), conceptual overlap of student engagement sub-construct definitions and operationalization may lead to different findings when comparing student engagement with facilitators and outcomes (Fredricks & McColskey, 2012). The lack of research on cognitive engagement and especially emotional engagement makes it difficult to determine whether it is really necessary to operationalize and define student engagement with these sub-constructs (see Janosz, 2012). Further research is essential to establish how both emotional and cognitive engagement relate to important educational outcomes and facilitators of engagement.

Student engagement can be a useful indicator of how well students are doing in achieving desirable academic and social outcomes. Monitoring student engagement could help us identify students who are on track for success and those who need additional help to persist and succeed. Measuring student engagement can provide valuable evidence for the quality of a course, learning activity, or instructional tool. Further work on developing effective measures of student engagement will increase our capacity to help students and improve instruction.

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