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# Coding Classroom Interactions for Collective and Individual Engagement

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This article characterizes "engagement in science learning" from a sociocultural perspective and offers a mixed method approach to measuring engagement that combines critical discourse analysis (CDA) and social network analysis (SNA). Conceptualizing engagement from a sociocultural perspective, the article discusses the advantages of a mixed methodological approach, and specifically how mixed methods can expand and enrich our understanding of engagement in certain science learning situations. Through this sociocultural viewpoint, engagement is defined as meaningful changes in disciplinary discourse practice, which captures the dialectical relationship between the individual and collective. The combined use of CDA and SNA integrates an individual's relative position in a group with her situated language use.

There has been a recent consensus that engagement is central to understanding and improving students' learning. In the areas of science, technology, engineering, and mathematics education, engagement is receiving more attention as these fields generally shift their emphasis from acquiring content knowledge to engaging in particular practices. Such a shift is mandated by new science and mathematics education standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; NGSS Lead States, 2013) that recognize growing engagement in specific disciplinary practices as a crucial learning outcome (see Sinatra, Heddy, & Lombardi, this issue).

Analyses of engagement from sociocultural perspectives are increasing in number (Crick, 2012; Dockter, Haug, & Lewis, 2010; González, Moll, & Amanti, 2013; Lawson & Lawson, 2013; Rumberger & Rotermund, 2012) as sociocultural views on learning become more appreciated (Barab & Plucker, 2002; Chaiklin, 1993; Engeström, 1999; Greeno, 1991; Lave & Wenger, 1991). Sociocultural views on learning also inform changes in conceptualization of and methodological approaches to motivation and regulation of learning, which may influence many engagement studies (Järvelä, Volet, & Järvenoja, 2010; McCaslin, 2009; Nolen & Ward, 2008; Turner & Patrick, 2008; Volet, Vauras, & Salonen, 2009; Zimmerman, 2008). Hence, sociocultural conceptualizations of and methodological approaches toward engagement may enrich the field by allowing researchers to explore a wider variety of questions (i.e., those raised from sociocultural views of the processes by which students come to engage in their groups, activities, and communities). These questions include the following: How does student engagement develop over time? How do social interactions shape student engagement, and conversely, how does student engagement shape social interactions? How does individual engagement connect to social and cultural contexts? A sociocultural perspective necessitates methods that go beyond individual measurement by characterizing and analyzing engagement as changes in participation that occur when students engage in social and relevant disciplinary practices (e.g., science learning in classroom communities).

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Researchers often conceptualize engagement in science education, as well as other domains, using a cognitive-focused approach, where engagement may be viewed as an individual construct (see, e.g., Fredricks, Blumenfeld, & Paris, 2004). Although an increasing number of these studies recognize the importance of social and cultural influences, such contexts may be considered as an extraneous factor residing apart from the individual (see, e.g., Lawson & Lawson, 2013). In contrast, the focus of the sociocultural approach is the instructional environment where students and teachers learn together (i.e., the context in situ, which is measured using authentic classroom activities and materials; Lave & Wenger, 1991; Roth & Lee, 2007; Vygotsky, 1978). Such theoretical differences (e.g., cognitive-focused vs. sociocultural) may then lead researchers to make different methodological decisions to characterize and measure engagement.

The primary objective of this article is to advance a novel methodological approach to characterize and gauge engagement in science learning using a sociocultural perspective, with engagement conceptualized as *meaningful changes in participation*. Engagement in science learning can be seen as a dialectic and dynamic process between the individual and the collective that is framed within the disciplinary practice of a community (e.g., a science classroom). Legitimate participants (e.g., teachers and students) contribute to the community of practice by taking on roles and responsibilities as they negotiate and develop a sense of belonging (Holland & Lave, 2009; Lave & Wenger, 1991). Furthermore, the practice of the classroom community is focused on the epistemic processes of scientific knowledge construction and critique. Within the context of the science learning, we use the terms *epistemic identity* to refer to the development of a sense of belonging within the knowledge-constructing classroom and *epistemic agency* to refer to the actual classroom practices associated with knowledge construction.

We now turn to a brief review of recent theoretical and methodological innovations in relevant literatures on motivation and self- and coregulated learning, and do so because scholars in these fields are interested in capturing the dynamics of interpersonal regulation in learning interactions, and thus provide useful methodological suggestions. Next, we discuss reasons for why different methodological approaches are used and how methods drawing on sociocultural perspectives can expand and enrich our understanding of engagement. When engagement in science learning is defined as meaningful changes in participation in relevant disciplinary practices, such changes in participation can be understood by examining epistemic discourses. These discourses, in turn, define the knowledge produced in the community. In particular, we show that the combined use of social network analysis (SNA) and critical discourse analysis (CDA)—applied within a sociocultural framework—allows researchers to examine and visually trace the dialectical relationship between individual and collective engagement.

## SOCIOCULTURAL PERSPECTIVES IN LEARNING AND ENGAGEMENT

Although diverse approaches exist under the name "sociocultural perspectives," a common root is found in Vygotsky's work (Vygotsky, 1978, 2012), along with the work of other 20th-century Russian theorists (see, e.g., Leont'ev, 1981; Luria, 1976). Vygotsky (1978) located the origin of higher order thinking in social interactions where participation in specific forms of interaction structures how individuals make sense of the world. Social activity organizes individual cognition from a sociocultural perspective, and learning involves the development of repertoires of practice that are situated within particular settings of activity. Epistemologically, this view is consonant with social epistemology (Goldman, 1999; Longino, 1990). Knowledge is not treated as an object, but rather as something that evolves during participation in disciplinary practices through development, critique, and revision. Whereas behaviorism and cognitive learning theories may view the context as an extraneous factor or "cognition plus," context is essential in sociocultural theory, which seeks to understand and describe the dialectical relationship between individual and social context. Based on the philosophies of Engels and Hegel, the dialectical relationship highlights that neither the individual nor sociocultural context can be defined without the other, and such a synergism can synthesize and strengthen our understanding of learning (Engeström, 1999; Wertsch, 1993).

### Dialectical Relationships in Motivation and Regulation

The importance of understanding the dialectical relationship between the individual and the social is increasingly recognized in regulation and motivation studies (see, e.g., Järvelä et al., 2010; McCaslin, 2009; Meyer & Turner, 2002; Nolen & Ward, 2008; Turner & Patrick, 2008; Volet et al., 2009; Zimmerman, 2008). Volet et al. (2009) pointed out that the conceptualization of regulatory constructs provides powerful ways to explain dynamics and relationships between individual and social but tend to stress one entity (i.e., either individual or social) and overlook the other. For those who focus on an individual's regulation process, studying how one adapts to the environment is of primary interest, whereas understanding the social context is deemphasized. For those who focus on coregulatory mechanisms, understanding the social system is more important, whereas individual adaptation is often considered an outcome of coregulatory processes. Thus, Volet et al. (2009)

argued for an integrative perspective that combines individual and social and suggested the need for cross-level analyses (see also McCaslin, 2009; Turner & Patrick, 2008).

Methodologically, although the main object of analysis varies depending upon conceptualization of regulation and motivation (i.e., individual within an environment, a social group as a unit), many researchers understand the importance of the situated and dynamic nature of interpersonal regulation and motivation (Järvelä et al., 2010; Nolen & Ward, 2008; Turner & Patrick, 2008; Volet et al., 2009; Zimmerman, 2008). Specifically, Turner and Patrick (2008) argued that self-reported data might allow researchers to access only hypothetical beliefs that individuals report (i.e., students often answer what researchers expect to see, assuming a hypothetical situation related to participation, subject preference, peer relationship, or teacher liking). Thus, researchers are limited in their ability to study how and why motivation changes over time. Researchers are therefore moving from gathering hypothetical and aptitude data via interviews and surveys toward tracing and capturing real-time interaction data via human observation or online traces. Azevedo, Moos, Johnson, and Chauncey (2010) suggested that online traces (e.g., keystrokes) can accurately model and measure the process of self-regulation because online interactions naturally leave traces (e.g., patterns and cadence of keystrokes may reveal levels of text monitoring; see, e.g., Gobert, Baker, & Wixon, this issue). Winne (2010) suggested that tracing online data as self-regulation is consistent with the conceptualization of self-regulation as a contextual event rather than an offline aptitude.

### Dialectical Relationships in the Classroom

As with regulation and motivation, individual and collective engagement may dynamically change within the sociocultural and historical classroom contexts in which development and learning are occurring (John-Steiner & Mahn, 1996; Putney, 2007; Putney & Broughton, 2011). In a classroom, engaging in disciplinary practices is outlined as the appropriation (i.e., taking something for use) of historically shared cultural resources (both physical and psychological) through participation in collective and individual activities. When participating in disciplinary practices, students use collectively shared and negotiated problem-solving procedures and cultural tools (e.g., scientific terms) that mediate their activities (Wertsch, 1993). Engagement in learning, from these perspectives, must be characterized as a dynamic process regarding how collective and individual practices are developed. In a classroom community, the collective practice begins with sharing and negotiating cultural resources, such as norms that promote learning (Putney, 2007; Wertsch, 1993). Cultural resources are distributed through an ongoing negotiation, which builds upon individual roles and responsibilities. Through this negotiation to regulate their activities, the individual student constitutes what she is and what she does situated within the classroom context. Hence, individual engagement involves processes of taking on new roles and responsibilities that contribute to building identity and agency (Holland, 2001; Holland & Lave, 2009; Lave & Wenger, 1991). For example, imagine a small group where a student gradually increased his participation in discussion. As a classroom norm that highlights broader participation is shared, increasing epistemic agency of this student could be observed as he comes to actively participate in the collective decision of planning, negotiating, and reflecting on these processes to achieve the goal of the group. This student may then refine his role and responsibility for making the group's decision as a mere observer to an active contributor. In turn, his growing frequency of engaging in such discussions would improve the quality of argumentation in the group, at least, from having a monologue to engaging in dialogical argumentation.

### Participation in Classroom Science

For science classroom communities, meaningful changes in practice can be framed in such a way as to participate in the negotiation and appropriation of the disciplinary epistemic and social norms and values consistent with scientific practices (Ryu, 2014; Ryu & Sandoval, 2012). Epistemic criteria of certain fields are not simply memorized or understood by participants in the knowledge construction activities. Rather, participants actively negotiate values and norms that motivate their ongoing engagement in the contexts in which these activities occur. In this way, all participation contributes to and changes knowledge. Participants carry out new roles and responsibilities regarding this knowledge (i.e., epistemic agency) and find themselves acting correspondingly (i.e., epistemic identity). With regard to engagement in science learning, collective engagement could mean that a classroom community (i.e., teacher and students) collectively negotiates an understanding of the disciplinary ideas, terms, and norms of the community of scientists. Individual engagement concerns how specific students change their modes of participation, which results in changes in roles and responsibility. Epistemic agency characterizes how students' actions and relationships are involved in building and critiquing knowledge, which inevitably shapes each individual's ontological being within the community (i.e., her science identity). Therefore, engaging in scientific discourse is fundamental to epistemic agency within a science classroom.

## METHODOLOGICAL CHALLENGES IN ENGAGEMENT STUDIES

We now discuss methodological issues and, in particular, issues concerned with sociocultural learning perspectives on

engagement. We address some issues raised when conceptualizing engagement as a multidimensional construct and discuss potential limitations of self-reports and interviews to measure engagement. Next, we move to review the affordances and constraints of observation protocols and disciplinary discourse analysis because these two methods attempt to address the shared concerns from sociocultural perspectives—the importance of social interactions and contextual factors in the characterization of engagement. We reflect how these methods may or may not capture engagement from a sociocultural perspective to gauge the dialectic and dynamic process between individual and collective that changes through participation, and then provide critique that addresses the limitation of these methods, which lead us to suggest the combination of critical discourse analysis and social network analysis as an alternative.

Many researchers agree that engagement is a metaconstruct that consists of multiple dimensions of involvement (e.g., behavioral, emotional, cognitive, agentic; see Sinatra et al., this issue) and exists on a continuum (Appleton, Christenson, & Furlong, 2008; Fredricks, 2011). However, studies of engagement have tended to focus on the conceptualization and measurement of one dimension, and relatively little information exists regarding the integration and interactions of these dimensions. Some have noted the difficulty in distinguishing between what characteristics define engagement (i.e., indicators that belong to the definition of the construct) and what characteristics cause engagement (i.e., facilitators or contextual factors; Skinner, Furrer, Marchand, & Kindermann, 2008). Lam, Wong, Yang, and Lui (2012) also pointed out the need for a clear demarcation between indicators (e.g., features that define student engagement, such as enthusiasm to do school activities) and engagement outcomes (e.g., grades, earned college credits). Lam et al. specifically asserted that verifying the consequences of engagement are important, and without making a clear difference between indicators and outcome, the outcomes of engagement cannot be fully examined.

Researchers have also identified some methodological issues in engagement research, which may rely on self-reported surveys and interviews using correlational analysis (see Greene, this issue). One issue is that self-report measures may be insufficient for constructing causal, mechanistic explanations for how students' engagement is related to classroom context and instruction. Self-report measures may not provide adequate information on how interactions in the classroom hinder or promote engagement with classroom disciplinary practices. Another issue with self-reported surveys and interviews is that engagement is measured at the particular moment when the interview or survey is conducted. Thus, it often loses the trace of development in engagement, and therefore may miss the underlying reasons for engagement or disengagement (see Gobert et al., this issue). In addition, because the measure often does not verify specific sources or targets of engagement, students tend to answer based on their hypothetical assumptions about what is or might happen (e.g., "I think a group activity would be helpful for me to refine my goal"), and the findings may reveal only general tendencies. Thus, self-report measures may not capture the process by which students change their engagement over time within a context (Fredricks et al., 2004).

Using individual-centered methods may then make it difficult to capture when and how students engage in practices to learn (i.e., the dynamic and dialectical relationship between the individual and collective development of participation in practices). For example, Ryu and Sandoval (2012) showed that individual students began to supply evidentiary justification when engaging in argumentation. They highlighted that this could happen because the need of providing justification emerged as a social request that asks for the interpretation of data to be counted as evidence. As such, the individual learning of providing justification can be captured better when describing the classroom community's collective development of understanding and commitment to evidence. Learning and development from a sociocultural perspective proposes that what begins with a collective, social phase of work is transformed into an individual phase, which is then understood within the collective community (Putney, 2007; Wertsch, 1993). This sociocultural perspective suggests that engagement in learning often reflects the ongoing participation in the creation of socially defined, distributed knowledge rather than describing it as individual, cognitive involvement that focuses on acquisition of existing knowledge through social interactions.

In a science classroom, cultural resources—including classroom norms that are based on scientific practices—are negotiated and appropriated over time by both the collective and individuals. For example, when a collective group engages in a specific science activity, the ways in which they formulate and reformulate their problems and tasks, allot responsibilities and roles, and take personal action need to be understood as both collective and individual engagement in practice. Therefore, the dynamic process of collective and individual engagement that is traced and captured over time (e.g., as relationships between the micro- and the macrolevel analyses) may adequately capture the evolution of dialectic relationships. Investigations into particular moments or a reliance on individual answers about hypothetical situations may be insufficient to gain an understanding of the picture of engagement in science learning.

In summary, whereas the importance of social interactions and environment is increasingly acknowledged in engagement research (Gresalfi, 2009; Lawson & Lawson, 2013), the dimensional approach can cause difficulties with regard to understanding engagement as dynamic and process oriented. The dimensional approaches tends to focus on individual-level analyses, where the role of social interaction and process is perceived to be extraneous and may be considered to be less important with

regard to providing an account of effective engagement in learning. This potential gap underscores the need for sociocultural approaches to be included in our efforts to understand engagement.

### Observation of Interactions That Explain Relationships as Engagement

Some researchers have used standardized observation protocols to collect predetermined and specified types of interactions to measure engagement. Such observation tends to focus on capturing the nature and quality of interactions, either to explain the relationship or to posit the characteristics of disciplinary practice interactions (e.g., planning and carrying out scientific investigations; Minner & DeLisi, 2012; Pianta, Hamre, & Allen, 2012). Compared to self-reported surveys or interviews, these methods can capture the relationships and interactions that affect engagement because the third-eye observer may be more objective than student participants. When using an observation protocol, the focus is on instructional teacher–student interactions, such as distinctive characteristics of high-quality teaching interactions (e.g., encouraging students to consider alternative explanations that arise from a particular line of evidence) or of highly engaged students (e.g., generating scientific explanations from experimental evidence). The result of such an observation protocol shows the frequency of targeted interactions, often used as professional development resources through diagnosing classroom interactions and evaluating curriculum intervention.

Pianta et al. (2012) developed an observational instrument that assesses classroom interactions (CLASS, for "classroom assessment scoring system"). They proposed a Teaching Through Interactions framework to conceptualize and measure the main features of classroom teacher–student interactions. The framework consists of several teacher–child interaction dimensions, including emotional climate, teacher sensitivity, student perspective, behavioral management, productivity, instructional learning formats, conceptual development, quality of feedback, and language and instructional modeling. Within this framework, the dimensions function as responsive teaching, motivation supports, management routines, and cognitive facilitation, and promote social-emotional, self-regulated, and academically cognitive engagement. Whereas CLASS and Teaching Through Interactions are recommended as cross-discipline assessment and teaching frameworks, the Inquiring into Science Instruction Observation Protocol (Minner & DeLisi, 2012) is designed to assess the quality of instructional interactions in science classes. Inquiring into Science Instruction Observation Protocol suggests core instructional moves to support students' engagement in scientific practices. The observation protocol categorizes teachers' instructional modes and strategies in detail and consists of in-classroom observation, postclassroom investigation experiences, and classroom leadership practices.

In these studies, standardized observation protocols are used in such a way as to capture and promote productive classroom interactions, such as teacher–student interactions or specific types of interactions used in scientific inquiry. Capturing (and promoting) such productive, higher level interactions is useful in addressing engagement, which also helps teachers get a sense of their classroom interactions. However, even though the observation protocol is standardized, having a well-trained observer who adequately understands classroom situations is critical because the interpretation of certain interactions relies solely on the observer's decision. Consequently, interactions could be misinterpreted depends on the quality of observers. As with self-reported surveys and interview methods, timing (i.e., determining when, how many times, and in what interval to observe) is critical to gain an accurate picture of engagement over a relatively long time span.

A standardized observation protocol expands the understanding of engagement as something situated and embedded in interactions and relationships, rather than as an inert tendency or attitude. There are some shortcomings, however, to using protocol-based interaction approaches to measure academic engagement. First, these codes do not necessarily facilitate descriptions of when, how, and what makes an individual highly engaged in the moment of a particular activity. Second, these approaches do not necessarily show the influence of social dynamics on interactions and engagement, which are associated with cultural contexts. Specifically, results of larger scale assessments hardly capture the changes and dynamic nature of the processes underlying teacher–student relationships and interactions. Whereas such results show high correlations between teacher sensitivity and students' positive attitudes toward participating in classroom activities, the ways in which teachers' comprehension of students' verbal or emotional cues could contribute to changes in their motivation or self-regulation remains unclear.

### Engagement as a Disciplinary Discourse Practice

Some researchers characterize student engagement as a disciplinary discourse practice, where the use of discourse is understood as a process of knowledge construction. Engagement in learning is defined as disciplinary-specific practice within the context of the subject class (Engle & Conant, 2002; Gresalfi, 2009; Herrenkohl & Guerra, 1998). Sociocultural theories and, in particular, situated and distributed cognition theories influenced this approach. Capturing ongoing participation is essential because knowledge is believed to be built upon and distributed in the context of use. Discourse analysis that captures verbal interactions, texts, emotional expressions, and gestures can be used to characterize ongoing participation. Such a broad view is referred to as

"big D" discourse (Gee, 1990, 2014), and data tend to be analyzed through an inductive and grounded approach, which characterizes discourse as emergent. Whereas the observation protocol predetermined the range for specified interactions, discourse analysis is widely open to capture and record a broader range of classroom interactions, which allows more context-dependent interpretations of data.

Herrenkohl and Guerra (1998) were among the first researchers to postulate changes in engagement as changes in discourse within the context of school science. Their analysis focused on how individual students become actively engaged in discussion and argumentation through the process of generating, manipulating, constructing, and monitoring ideas. They defined being engaged in disciplinary learning as members of a community developing a collective sense of "purpose and accomplishment" and, thus, developing dispositions toward learning. Engle and Conant (2002) further developed the idea of disciplinary engagement by examining discipline-specific discourse and asserted that productively engaging in science means that students' arguments for the methods of seeking evidence, and subsequent claims made, become more sophisticated over time. Engle and Conant also focused on tracing the moment-by-moment development of argumentation and conceptual understanding as evidence of productive disciplinary engagement. By emphasizing the use of argumentation within the relevant content area, these researchers claimed to be able to unfold and capture how individual students develop cognitive and social engagement. Of interest, whereas Herrenkohl and Guerra considered agency development to be the result of successful engagement, Engle and Conant viewed being successfully engaged as a condition that results, in part, due to increased agency (i.e., increased responsibility). Alternatively, Gresalfi (2009) conceptualized both disciplinary and interpersonal engagement as classroom practices and characterized discourse changes in the decision-making process for both interpersonal interactions and mathematical thinking and reasoning. Similar to Engle and Conant and to Herrenkohl and Guerra, Gresalfi considered establishing the propensity to engage as the result of participating in classroom mathematical practices.

To summarize, although sociocultural perspectives on engagement emphasize the dialectic relationship between individual and sociocultural practices, empirical studies using either observation protocol or discourse analyses have showed some limitations in teasing out this relationship. The observation protocol approach (Patrick, Anderman, Ryan, Edelin, & Midgley, 2001; Pianta et al., 2012; Pintrich, Conley, & Kempler, 2003) seems to consider social interactions and other contextual influences to be broader factors that show correlations with changes at the individual level. As such, results from protocols do not provide an explanation of *how* changes occur. The discourse analysis approach puts much more emphasis on how collective engagement in discourse practices contributes to individual learning dispositions. However, the opposite direction of change—how an individual student may contribute to collective and social practices—is less often described, although the nature of collective practice must be shaped by the contributions of individual members. Consequently, the analysis does not show how individual and collective practices are dynamically linked and work together to influence each other.

## ENGAGEMENT THROUGH THE SOCIOCULTURAL THEORY: USING CRITICAL DISCOURSE ANALYSIS AND SOCIAL NETWORK ANALYSIS

The sociocultural perspective theorizes that engagement in learning first occurs on the social plane (i.e., between people as an interpsychological category) and then is internalized to the individual plane (i.e., within the student as an intrapsychological category; Putney, 2007; Wertsch, 1993). To be consistent with this theoretical approach, a *linking* analysis is required that connects collective and individual engagement. The analysis also seeks to describe a *trajectory* revealing how collective interactions—in which students share and negotiate norms, values, and resources—are related to changes in individual discourse, which reflects students' roles and responsibilities. In turn, the linking analysis also needs to show how changes in individual engagement may develop and shape collective engagement. This trajectory can be multilayered, from the individual's engagement in classroom work to small-group collaboration, to engagement in larger and/or different groups.

For an effective linking and developmental-trajectory analysis, we propose a method that combines CDA and SNA. Discourse analysis has been used to examine the collective process of shared regulation as a group of students negotiate, share, and develop meaning together. SNA aligns with a recent methodological innovation that collects real-time online trace data, which conceptualizes self-regulation of learning as a contextual event (Järvelä & Hadwin, 2013; Winne, 2010). Combining CDA and SDA can facilitate understanding about why particular episodes are selected for further in-the-moment, contextualized, detailed discourse analysis rather than relying only on interpretation by allowing researchers to effectively trace, analyze, and represent this dynamic process of engagement.

In the following, we review the capabilities of CDA and SNA and how each method is used to complement the other. Then we provide a specific example that shows how these methods are combined to address individual and collective engagement in an elementary science classroom.

### Critical Discourse Analysis

Among diverse forms of analyses, CDA facilitates linking individual and collective engagement because discourse

use is interpreted in light of the dynamics and context of social practices. CDA analyzes not only language use and its relationship with social interactions and relationships but also the implications in terms of status, solidarity, distribution of social goods, and power (Gee, 2004). By being "critical," CDA broadly suggests that discourse is not used neutrally and must be evaluated and questioned (although "critical" is often also interpreted in a more political sense, as CDA is primarily used to study social power abuse, dominance, and inequality issues; Rogers, 2011).

CDA provides an analytical frame that bridges different layers (Van Dijk, 2001) and therefore examines levels of individual and collective aspects of practices. Such a multilayered analysis commonly incorporates a transtextual layer (e.g., frame, ideologies, historicity), an intratextual layer (e.g., topics, word units, text subject), and an agent layer (e.g., patterns of action, position, roles of interaction). Discourses are interpreted from argumentation structure and linguistic function, as well as from the viewpoint of interpreting social situations. For example, Anagnostopoulos (2003) analyzed how a classroom community resolved their conflict and tensions around the use of a common racial slur from two layers. This study showed how test-oriented texts (e.g., comprehension focused) hindered a teacher from engaging in a racial issue discussion. Students' engagement with the novel was influenced from social relations in the classroom (e.g., relationship between White and African American students) and altered discursive conventions in the classroom. The literature on CDA categorizes several ways of bridging these levels, including individual members and social groups, actions and process, context and social structures, and personal and social cognitions (Van Dijk, 2001). Fairclough's (2013) notion of "orders of discourse" (i.e., ways of interacting, ways of representing, and ways of being) or Gee's (2004) "social discourse" (big D discourse) provides an analytical framework that involves the way in which the use of language is constructed by situated identities. In other words, CDA can suggest why certain people engage and others do not engage in a particular time and place, and thus take up certain positions. Gee (2004) suggested four levels of analysis, consisting of social language, situated meaning, cultural models, and Discourse. Whereas he did not explicitly mention that his CDA approach provides a way to analyze the relationship between individual and collective practice, analyzing and tracing socially situated identity and agency across the levels of social languages, situated meaning, cultural models and discourse helps researchers locate and connect the characteristics of individual and collective engagement. Drawing on this approach (Gee, 2004, 2014; Gee & Green, 1998), CDA is used to address individual and collective engagement by closely examining how particular students contribute to argumentative discourses, in accordance with the different ways in which they perform their roles or express their positions to promote or hinder their participation in the argumentation.

### Social Network Analysis

SNA is used to gauge the relationships among social entities, as well as the patterns among these entities (Wasserman, 1994). SNA is being used more frequently to investigate a wide variety of educational issues, such as peer influences on youth behavior (Ennett et al., 2006), the degree of using educational games for knowledge construction (Shaffer et al., 2009), and the nature of teacher networks (Penuel, Riel, Krause, & Frank, 2009). As an analysis tool addressing engagement, a main aim of SNA is to characterize and visualize engagement by tracing the shape of and changes in participation over time.

SNA focuses on analyzing either the structure of relationships or the positions of individuals in the network (Wasserman, 1994). SNA assumes that the individuals who compose the network are influenced by its organizational structure. The positions of individuals within a structure are traced through an analysis of the number, shapes, and lengths of ties and paths, that is, who knows whom and who shares what with whom. SNA produces diagrams consisting of nodes and lines. Each member of the social network is represented as a node, and the line connecting two nodes represents the interaction between two members.

Whereas CDA provides an interpretation for why and how something happens in engagement with critical reflection, SNA visualizes what is happening in relationships through the flow of available artifacts and knowledge, which is not otherwise readily discernable. For example, if one node has many links to other nodes, SNA assumes that the node has a central role in the targeted activity. Conversely, a node is isolated if it has no links to another node. SNA is also used to diagnose bottlenecks or breakdowns in participation, which are typically caused by hierarchical (academically or economically), ethnic (dominant ethnic group vs. minority group) or tenure-oriented (old timer vs. new participant) relationships among members.

Clique analysis (Aviv, Erlich, Ravid, & Geva, 2003) examines these characteristics of a subcommunity to characterize the evolving nature of collective engagement. A "clique" is a smaller set of networks inside a bigger set, in which the agents are more closely linked and tied together than the other members in the network. In a typical classroom discussion, the teacher tends to be the single node with the largest number of links. When only one clique centered on the teacher is identified, it means that the teacher and a few students dominate the classroom activity. If the same clique is identified across different activities (e.g., across subjects), this can be called a fixed pattern of classroom engagement. Ideally, several different kinds of

cliques exist and overlap across different activities; this can be called a distributed engagement.

The power of SNA is to provide a tool for measuring engagement by tracking the shape of and changes in participation over time. In this way, researchers can visualize and characterize engagement in authentic learning environments (e.g., students engaged in collaborative group work while conducting a scientific investigation) when combined with CDA, which provides a way to characterize the dynamic exchange between individual and collective discourse practices.

## EXAMPLE OF SOCIAL NETWORK ANALYSIS AND CRITICAL DISCOURSE ANALYSIS: LOCATING INDIVIDUALS IN EVOLVING COLLECTIVE ENGAGEMENT

To exemplify and illustrate the utility of a method combining SNA and CDA, we provide a brief review of a study conducted by the first author investigating collective and individual engagement in a science classroom (Ryu, 2014; Ryu & Sandoval, 2012). The study took place in a mixed-grade classroom with nine Grade 3 students and 12 Grade 4 students. Note that the characteristics of interactions and engagement coded in this example are not generalizable, although some recognized patterns could model representative interactions and characteristics of engagement in a classroom. An experienced elementary school science teacher manipulated the participation of class discussions by encouraging less engaged students to talk more while limiting the participation of dominant, active students. She also assigned and rotated different roles and responsibilities. Over the course of the academic year, students' participation showed dramatic changes, and the teacher gradually decreased her instructional scaffolds and prompts. A question of the study was whether and how individual and group engagement would change within smaller groupings of students when participating in science instructional activities.

Figure 1 shows an example of combined use of SNA and CDA to examine engagement in learning. The analysis features an English-language learner, third-grade, male student's changes in engagement from an entire-classroom discussion to a playground group (friendship-based composition) to a science class group (mixed-ability group). The two diagrams also show the comparison between his engagement in disciplinary learning and his general tendency (increasing/decreasing frequency of talk) regarding how often he talks and with whom. From Figure 1a, he had no interaction with others. However, at this earlier phase of the new academic year, other groups' interactions seemed less active, as only a small number of links were generated. From Figure 1b, the diagram suggests that he was engaged in a mutually interactive type of discussion with other students. He seemed to pick up other members' ways of providing comments and questions, as he often used "It seems to me, though," a phrase that tended to be used by others but not by him. At this moment, he fixed a problem to connect electronic circuits to the wings of helicopter by making the helicopter body stronger with LEGO blocks. When the group members praised him, he responded, "That's sort of what my family does." He highlighted that car tuning requires science and engineering knowledge, just like their helicopter project. His expertise outside of the science classroom community (LEGO-building expert) helped him to take new roles in his group and enabled him to engage in scientific argumentation more often. For example, when diverging results were gathered from one experiment, he claimed that the group had to ensure all circuits were well connected.

CDA is useful in interpreting the situated meaning of talk and its role in a particular context that determines one's engagement. The foci of the CDA include the following: (a) the goals for knowledge construction, as recognized by group members; (b) the meaning of science activities; (c)

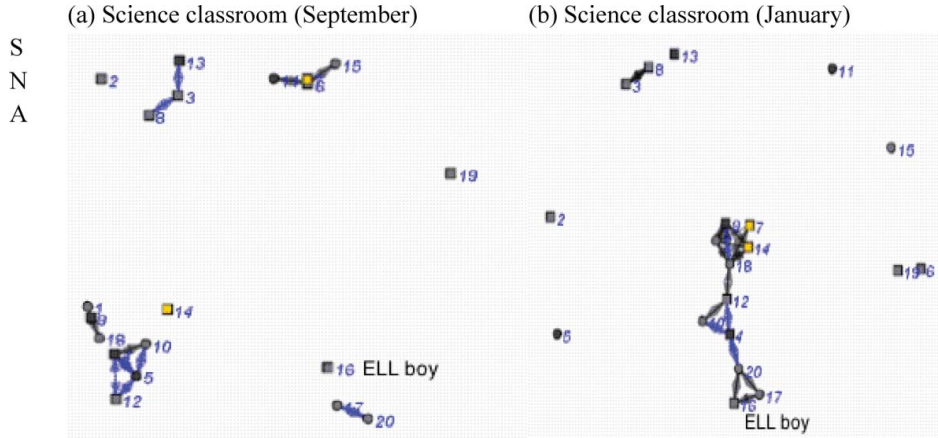


FIGURE 1 A student's changes in engagement in his science classroom community. *Note*. ELL = English language learner; SNA = social network analysis.

the roles that students in a group adopt to shape goals and perform activities; and (d) discussion and argumentation as discourse. As such, the analysis of linking individual and collective engagement focused on how the students' building of epistemic agency was mediated by their social dynamics and how the available cultural resources influenced their engagement in scientific argumentation. As shown in Figure 1, the student was able to incorporate his LEGO expertise into the science classroom, which helped him connect his family's identity to his science and engineering agency and enabled him to engage in scientific argumentation more often. To synthesize these complicated aspects and relationships, a constant comparative approach was repeatedly used to ensure the findings of the analysis.

Conducting CDA for all conversations over a period of time is time-consuming and labor-intensive work. Moreover, CDA carries the risks of a wrong interpretation, because the interpretation relies on the researcher's observations and inferences. SNA ameliorates these issues by providing some useful ways to complement CDA's weakness. For example, SNA can be used to determine a student's density and centrality in a group by basically assuming that a central member will have a larger number of links. SNA also shows who talks to whom, how often, and on what particular topics.

Combining CDA with SNA results in greater efficiency, and potentially greater accuracy in gauging engagement. CDA is essential to examine whether his role improves over time. But after conducting CDA for a few important episodes over time, SNA provides a way to confirm the changes as the centrality and density of his participation are likely to be changed accordingly. In this way, one's changes in discourse use are connected to changes in interactions and participation, which accounts for the changes in engagement.

## LINKING INDIVIDUAL ENGAGEMENT AND COLLECTIVE ENGAGEMENT THROUGH CODING ARGUMENTATIVE DISCOURSES

Scientific knowledge emerges from collaborative and critical argumentation, which is a constructive and social process where individuals compare, critique, and revise ideas (Nussbaum, 2011). Classroom discussions based on argumentation are characterized by students and teachers developing critical questions and critiquing connections between evidence and scientific explanations (Chin & Osborne, 2010). From a sociocultural perspective, students ascribe the gaining of power to the argumentative discussions that they produce as they work on knowledge construction in the classroom community (Fairclough, 2013; Jimenez-Aleixandre & Erduran, 2007). Therefore, gaining power in a classroom knowledge community is related to epistemic agency. Moreover, the relationships among students, including power dynamics and individual students' roles or responsibilities, are likely to be revealed when students engage in argumentation because students make substantive contributions collectively and individually when a topic is argued in a serious manner.

Visualization is a strong tool to represent the changes in interactions and the distribution of interaction as interpreted through changes in roles and positions. This visualizing process examines the structure of interactions (i.e., distribution and degree centrality), the prevailing elements of discourse use, and the influence of discourse use on positions and roles. In particular, visualization analysis seeks to identify the patterns of interactions that emerge from argumentative discourse use, as well as whether and how students change their engagement, not only in their groups but also in the entire classroom discussion. Among many visualization tools, the Social Network Image Animator is used to visualize the dynamic changes of the group interactions (Bender-deMoll & McFarland, 2003).

Characterizing these interpersonal interactions contributes to a better understanding of the nature of engagement in learning because previous research has found that students are more likely to make meaningful contributions when their argumentative discourse is moved forward collectively, rather than when each individual independently develops the argumentative discourse. Characterizing interpersonal interactions may allow researchers to see the trajectory through which academic engagement develops and evolves. At the same time, capturing and characterizing the discourses used for argumentative interactions may suggest the guidelines or distinctive features of interactions that represent productive engagement in learning.

We return to a study conducted by the first author (Ryu, 2014; Ryu & Sandoval, 2012), which involved elementary students engaging in group activities that discussed scientific topics, to illustrate the visualization and characterization of interpersonal relations. In analyzing the group activities, collective argumentative interaction was operationalized as a series of related discourse used in an episode that emerged in the two groups. A new episode was identified when the participants shifted to a new topic. All episodes involving collective engagement had two or more participants. The first author identified the episodes in which the students had opportunities for convergence, for the development of different solution paths, or for engagement in competitive talk in order to find collectively engaged conversations. The collective, argumentative interaction coding categories were as follows: (a) sharing and confirming understanding, (b) mutual contribution to develop ideas and draw conclusions, and (c) iterative and evolving nature of talking. An episode could be coded using more than one coding category (see Table 1 for details).

Individual argumentative interaction was operationalized as individual discourse use, in which one recognized, clarified, and monitored science language and requests for reasoning. The coding categories were as follows: (a)

TABLE 1
Tracing Collective Argumentative Interactions

| *Social Attributes* | *Characteristics* | *Discourse* |
|---|---|---|
| Sharing | Joint attention, shared orientation toward activities | What are "WE" going to do? |
| | Allow and encourage each other to provide ideas | Feel free to provide other opinions. |
| Mutual | Reciprocal interaction | Let's hold on for a second and hear X's idea. |
| | Joint negotiation of norms | |
| | Shared goals and refining those goals | |
| | Provide feedback focusing on refining ideas/goals | |
| Iterative and evolving | Evaluate and improve ideas in light of the group's goals and tasks | That's good, but we can improve. |
| | | We need to think about how we can convince the rest of the class |
| | Incorporate the shared negotiation with the discussion of emerging ideas | |



providing monitoring/rephrasing/comprehension comments, (b) identifying tasks and taking on roles, (c) challenging others' perspectives, (d) requesting evidence and further explanation, and (e) summarizing and coordinating theories/ideas with evidence (see Table 2 for details).

Epistemic agency was observed when a student not only participated actively in setting goals but also planned, negotiated, and reflected on the processes for achieving the goals. Consequently, the frequency of engaging in argumentation increased as a student began to actively express his or her epistemic agency, but even more important, the change in the qualitative nature of engaging in argumentation was highlighted. The coding categories that traced this qualitative nature included the following: (a) providing monitoring/rephrasing/comprehension comments, (b) identifying tasks and taking on roles, (c) referring to others' ideas or challenging them, (d) requesting evidence, and (e) identifying oneself in relation to one's tasks.

## CHANGES IN COLLECTIVE ENGAGEMENT

The combined use of CDA and SNA allows a description of the evolving nature of collective engagement, consisting of four phases. There are four phases of evolving engagement, which represent collective and individual argumentative interactions (see Figure 2). The phases consist of (a) discordant, (b) sharing ideas, (c) mutual, and (d) distributed.

### Discordant

In this phase, no collective argumentative interaction was observed. Although individual awareness occurred through the posing of a monitoring or comprehension question, the awareness tended to be interrupted by simple rejection or disagreement. Thus, there was no active interaction in the form of the exchange or sharing of ideas, and the ideas were rarely used to improve or elaborate on an idea together. Only a small number of links were generated in the SNA, and these links were centered on only a couple of participants.

### Sharing Ideas

The students were open to providing ideas to each other in this phase. Thus, several claims and ideas were introduced to the group, often followed by questions that sought elaboration. However, in this phase, the students tended to focus on "providing" ideas rather than on discussing one idea by revising or building on it. Individual students seemed to be aware of and to monitor "what is going on here," indicating both metacognitive awareness and some epistemic agency. The students seemed to know their own and others' ideas and interests because, without understanding them, it was simply impossible to provide ideas. However, the students had yet to make progress toward a collective discourse aimed at further understanding or reaching a consensus, thereby indicating a reduced level of epistemic agency.

TABLE 2
Tracing Individual Argumentative Interactions

| *Cognitive Attributes* | *Characteristics* | *Discourse* |
|---|---|---|
| Awareness of engagement | Know "what's going on" | Provide monitoring/rephrasing/comprehension comments |
| | Goal, topic, members, roles, ideas | Identify tasks and assume roles |
| Complementary engagement | Build on, connect, refer/cite, critique, improve | Refer to others' ideas and challenge others' ideas |
| | | Request evidence/explanation |
| | | Summarize and coordinate ideas with evidence |
| Positioning | Recognize specific roles | Identify themselves in relation to their tasks |
| | Acknowledge intellectual equality | |

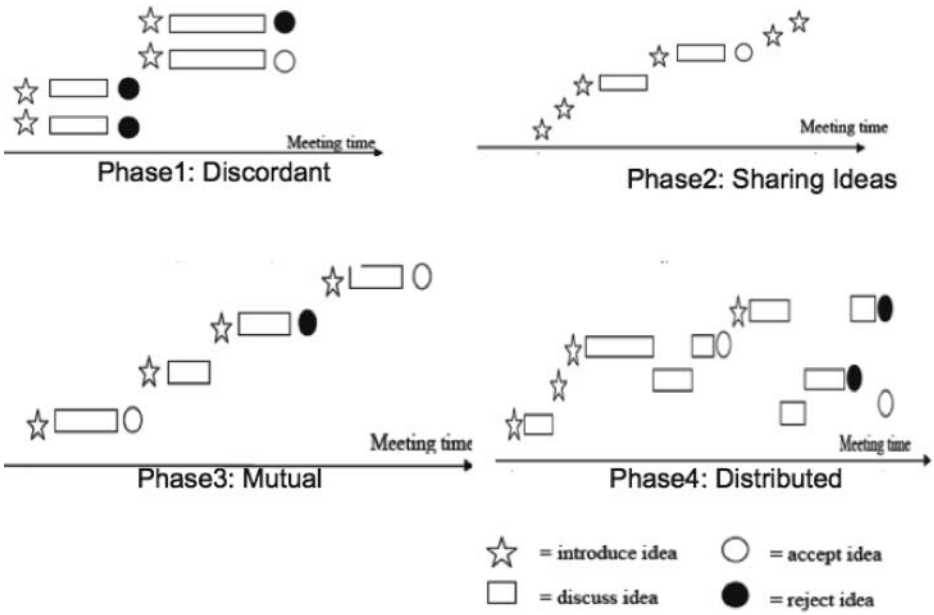


FIGURE 2 Evolving collective engagement.

### Mutual

The students' contributions to the argumentative discourses were mutually interactive in this phase. Only a small number of ideas emerged, with only one or two ideas discussed in depth. The students provided feedback on ideas or goals and the revised and improved upon them. Compared to the sharing phase, in which the requesting of reasoning or the clarifying of relationships or mechanisms almost never appeared, the students were more likely to request reasoning and provide mechanistic explanations. Note that this did not happen with a single contribution from one individual. Instead, the students' ideas and arguments could be elaborated as one student attempted to respond to others' questions. In this phase, however, once an agreement was reached among the group members, the students were satisfied with the decision and hardly revisited the idea. The participation rates differed between the active participants and others, although all the students increasingly participated in the discussion.

### Distributed

The difference between mutual and distributed phases is that participation is equally distributed in mutual engagement but not necessarily in distributed. In the sharing ideas and mutual phases, there were some centered contributors who proposed or elaborated on ideas. Even though multiple lines of ideas were initially discussed in the distributed phase, the students also identified and negotiated the intersection of these ideas. Such discussion at the intersections enabled more students to participate and take responsibility. Instead of a few students making a single line of argument, the students iteratively visited different ideas. The students also evaluated and improved the ideas in light of the group's goals and tasks. Furthermore, the students incorporated the shared negotiation into discussions of emerging ideas. Individual students were more likely to recognize specific roles in this phase because of the need to iteratively seek, evaluate, and provide feedback on ideas in order to produce better ideas. Thus, the students were aware of their own and others' contributions.

## CONCLUDING REMARKS

The four phases of evolving engagement (discordant, sharing ideas, mutual, and distributed) represent the process by which the combined use of CDA and SNA can enable researchers to better characterize the dynamic nature of individual and collective engagement. Furthermore, these combined methods may result in increased accuracy in measuring engagement because CDA captures how individual roles changes within groups, with SNA providing a way to view how these changes affect the group's overall interactions and participation over time. When viewing engagement as meaningful changes in disciplinary discourse practice, the combined use of CDA and SNA efficiently captures the dialectical relationship between the individual and collective necessary to characterize engagement in science learning as it happens within the classroom.

Different views on learning influence the conceptualization of engagement and the research methods used to characterize, measure, and analyze engagement. From a

sociocultural perspective, learning is defined as changes in participation; thus, engagement in science learning needs to capture the dynamic and dialectic process that links individual and collective engagement as students construct scientific knowledge and engage in scientific practices. One of the challenges in engagement research is that sociocultural influences are considered to be a broader factor that merely suggests correlation with the characteristics of engagement (Gresalfi, 2009; Lawson & Lawson, 2013; Olitsky, 2007; Olitsky & Milne, 2012; Rogoff, 2003). In contrast, when the details of interactions or discourse uses are placed at the forefront of the engagement process, sociocultural influences and exchanges take on a centralized importance to the analysis.

The first author attempted to characterize the qualitative difference of engagement by capturing and tracing the dynamic relationship between collective and individual argumentative interactions. Such characterization informs how and why engagement influences students' success or failure in science activities. Informed by distributed cognition and social practice theory, the combined use of CDA and SNA situates the linking of individual and collective argumentative interactions as a method to reveal the ways in which the development of individual epistemic identity and epistemic agency are attached to collective engagement. The recognition of goals and tasks or the adoption of specific roles and responsibilities can be found in the students' interactions, especially through their use of argumentative discourses. The emerging, shared collective interactions among children influence individual argumentative discourse use, which reflects one's metacognitive awareness and epistemic agency; in other words, requesting reasoning helps one to refine and take on a new role and responsibility or to develop a disposition. Engagement in learning is therefore measured by the specific contributions that students make toward achieving their goals in related practices. Although several studies have found that individual goal orientation and developing a sense of monitoring and achievement seem to be positively influenced by students' active participation in collaboration, they have not determined what specific aspects of this collective engagement are positively linked to individual goal orientation or monitoring. In the first author's analysis, when a group or class was more likely to engage in mutual or iterative and evaluative collective engagement, the students asked each other about individual goal recognition.

Through a combination of CDA and SNA, the relationship between individual and collective argumentative interactions is clarified, showing the evolving nature of engagement in learning. This combined method may overcome some limitations of using only one approach (i.e., either quantitative or qualitative analysis). The interpreted meaning of discourse use is confirmed and warranted through the use of SNA. CDA, on the other hand, provides a theoretical perspective and an analytical framework that bridges different levels of practices and enables researchers to interpret diverse interpersonal interactions. However, because CDA is focused on language in use, it is somewhat limited with regard to following changes in participation in activities as they develop. Thus, SNA is used to discover the dynamics of relationships and to visualize the changes in engagement over time. The combined use of both methods integrates individuals' relative positions in a group with their situated language use.

Our position reflects the idea that engagement in learning can be described in such a way as to link individual and collective engagement. Furthermore, such a description can appreciable expand our understanding about engagement. The exemplary analysis suggests that students' changes in collective engagement are related to individual engagement, and vice versa. The phase of collective engagement evolved when the students took on specific roles and more responsibility. In turn, such evolved collective engagement provided the students with more opportunities to make contributions, through which they could assume roles and responsibilities. This approach shows the promising advantages of using a combined method to integrate and visualize findings.

The interpretation of students' interactions, however, relies largely on existing sociocultural learning theories and on the researcher's inferences. Thus, future research should implement methods that make the data more accessible, perhaps through the use of other combination methods. For example, although diverse and advanced techniques of measures in SNA are available, initial analysis focused only on basic skills for analyzing networks. In addition, understanding the interplay between collective and individual engagement may allow teachers and even students to improve their participation. Thus, it is interesting to consider how the results of CDA and SNA for addressing engagement could be available to teachers (and students) and how they could be used as a tool to improve engagement. For researchers, understanding and addressing the interplay between collective and individual engagement can be beneficial to improving the design of learning environments.

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