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Commentary: Reconceptualizing momentary engagement through the lens of conceptual change learning

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Abstract

This commentary reviews the five papers featured in this special issue, which foster a cross-disciplinary discussion on momentary engagement (ME). The papers represent diverse theoretical perspectives and address key research questions central to understanding students' ME. The commentary approaches each paper through the lens of conceptual change, focusing on the learning processes needed when the information to be acquired is inconsistent with the existing theoretical frameworks. Methodological challenges in measuring ME within the context of conceptual change are explored, moving beyond traditional acquisition type of learning. The variation in quality and depth of momentary engagement is also discussed, distinguishing between different modes of active learning and engagement. Further attention is given to the complex, dual role of factors such as learner characteristics, prior knowledge, and epistemic beliefs in shaping ME, particularly in domains requiring radical reorganization of initial beliefs. Finally, the potential for constructing an integrated model of ME is discussed, in alignment with the holistic approach to ME implied by the papers in this issue. The author emphasizes the importance of studying ME's interconnected components within both the individual and the context, employing varied methodologies and accounting for different learning types. The implications of integrating different theoretical frameworks are discussed in relation to developing interventions aimed at enhancing students' ME in the classroom context.

Keywords: Conceptual Change; Holistic approach; Momentary Engagement

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1. Introduction

The parable of "the blind men and the elephant", common across many traditions, illustrates the limits of individual perspectives. Each blind man describes only a part of the elephant, without realizing the limited viewpoint. This metaphor highlights the need for multiple perspectives to fully grasp a complex phenomenon and find common ground. In this context, I will discuss the five contributions in this special issue, each addressing students' momentary engagement (ME) from a different theoretical and methodological perspective. These varied perspectives reflect the scope of the EARLI funded emerging field group *Integrated Model of Momentary Learning in Context* (IMMoLIC), which aims to synthesize distinct lines of inquiry and identify both differences and useful synergies among various traditions.

In this commentary, I will address the significance and potential limitations of various aspects highlighted in each paper focusing on a specific kind of learning, that of conceptual change (CC). Emphasis will be placed on a more complex type of CC, where major changes in our knowledge system occur during learning and development, especially following exposure to counter-intuitive science and mathematical concepts. When the information to be acquired contradicts existing beliefs or presuppositions, radical knowledge restructuring is needed (Vosniadou, 1994). For example, children struggle to understand the counter-intuitive notion that we live on the outside of a spherical earth, requiring the reorganization of presuppositions such as the earth being flat and stable, unsupported objects fall, or up/down gravity (Vosniadou & Brewer, 1992).

A recent constructivist approach to CC, the Framework Theory approach, suggests that children form naïve theories before formal science instruction, based on their experiences and cultural context (Vosniadou, 2013, 2017; Vosniadou et al., 2008). These naïve theories form framework theories, i.e., skeletal structures grounding deep ontological commitments and forming loose but coherent explanatory systems (Vosniadou & Mason, 2012). Because scientific theories differ significantly from the framework theories, learning science requires many conceptual changes involving new modes of knowing, new ways of reasoning and changes in categorization, representation and students' epistemic beliefs (Vosniadou, 2017). Unlike Posner's classical approach (Posner et al., 1982), CC is not merely the replacement of one theory with another but rather a slow and gradual process during which misconceptions and fragmented conceptions may emerge. Indeed, empirical evidence shows that CC can occur without intentional learning, with students changing from intuitive to scientific conceptions without being aware of the change, disrupting the coherence of initial frameworks (Vosniadou, 2003).

ME refers to a student's immediate interaction with a learning task, occurring over brief intervals, in contrast to macro-level engagement, which encompasses extended activities and larger groups. This commentary has a dual focus: to explore ME both as a momentary, micro-level phenomenon and as a redefined, holistic construct. At the *micro-level*, applying CC theory allows us to examine ME as a sequence of real-time learning moments, during which students actively confront and attempt to reconcile discrepancies between prior knowledge and new information. In this process, I will also consider the complex interactions among various factors that should be accounted for when measuring ME within the CC framework. This perspective offers insights into how learners actively work through conflicts in understanding, shedding light on the pathways of CC. In parallel, at the *meta-level*, CC theory provides a foundation for reconceptualizing ME itself, challenging and expanding current frameworks to develop a more holistic, integrated view. By identifying gaps in existing models of ME, I aim to use CC theory to capture ME's complexity as a dynamic, interdependent system.

2. Measuring momentary engagement: Rethinking the "how" and the "what" in conceptual change type of learning

2.1 Methodological Reflections: How to measure ME

If ME is conceptualized not simply as the addition of emotional, motivational, cognitive, and behavioral components, but as an integrated meta-construct (Fredricks et al., 2004; Symonds et al., 2024), it requires measurement approaches that capture this holistic view. Haataja and colleagues (this issue) suggest that "multiple data channels can contribute to a better understanding of the multidimensional nature of momentary engagement". Therefore, engagement must be assessed across varying grain sizes (micro to macro) and using multimodal measures to capture its dynamic nature (Fredricks & McColskey, 2012).

The five studies explored different aspects and levels of ME using diverse methods and measures. Haataja and colleagues combined subjective and objective data from natural classroom settings, analyzing cognitive and behavioral ME during collaborative learning (CL), with a focus on within-group variations. They used electrodermal activity and self-reports to assess collaboration in real time. Renninger and colleagues studied cognitive (executive functions) and behavioral (participation, cooperation) engagement during collaborative math problem-solving, using discourse analysis to track engagement across problem-solving phases. Their online collaboration study revealed engagement fluctuations that traditional observations often miss. Tang and colleagues employed experience sampling to examine emotional and motivational correlates of optimal learning moments, applying network analysis to explore ME relationships. Baines and colleagues conducted a multi-method study, assessing engagement at momentary, classroom, and school levels through self-reports, peer questionnaires, and science tests, supplemented by teachers' ratings of attention and behavior. Symonds and colleagues used the ORACLE tool in a large-scale study involving 92 Irish schools to categorize students based on behaviors, social interactions, and proximity to teachers.

These methodological tools range from traditional, easy to administer measures (e.g., self-reports) to novel approaches (e.g., physiological measures). Regarding the strengths and limitations of the different methods for assessing engagement, it seems important to triangulate engagement through the combination of various measures (Fredricks & McColskey, 2012). The contributions in this issue reveal this potential, as most researchers attempt to integrate different tools. For example, Haataja and colleagues found that while physiological synchrony reflected the collaboration process in authentic learning situations, situated subjective self-reports more effectively captured regulatory strategies. They argued that the relationship between physiological synchrony and engagement might not be straightforward, requiring consideration alongside students' appraisals for a complete understanding. Other researchers argued that self-reports, though useful, have limitations such as developmental suitability, interpretation issues, overestimation bias or accuracy concerns (Appleton et al, 2006; Fulmer & Frijters, 2009). They suggested combining self-report data with teacher rating scales (Skinner et al., 2009), observational methods although valuable can be susceptible to observer bias, similarly eye-tracking and physiological measures need to be complemented with contextual information. For example, in the CC context, Mikkilä-Erdmann and colleagues (2008) argued that while eye-tracking is useful for revealing cognitive processes during learning from scientific texts, it should be paired with think-aloud methods, interviews and other techniques. Triangulating findings from multiple tools ensures more reliable conclusions.

When students engage in scientific inquiry, it is also crucial to collect data without disrupting the flow of their activities. The experience sampling method allows real-time data collection in natural contexts, reducing recall bias by prompting students to respond at several points throughout the day (Bolger et al., 2003; Hektner et al., 2007; Inkinen et al., 2020; Sinatra et al., 2015). However, the content of these questions and the interpretation of children's responses are important considerations. The same concern applies to the self-reported measures used in the various studies in this issue. For instance, in the CC framework, different methods of questioning, such as forced-choice versus open-ended formats yield different insights. Vosniadou and colleagues (2004) showed that different questioning methods affect children's responses regarding phenomena as the shape of the earth and the day/night cycle, eliciting different forms of knowing and reasoning. Open-ended questions require children to generate an explanation (*If you walked for many days in a straight line, where would you end up? Is there an end or an edge to the earth? Would you ever reach the end/edge of the earth? Would you fall off that end/edge? Why? / Why not*?) rather than simply recognizing the correct scientific one among alternatives (*Is the earth round or flat? If it's round/flat, does it look like a circle or a ball?*) (Vosniadou & Brewer, 1992). Different interviewing approaches provide varied insights into how children approach their ideas, become aware of them, reflect on their knowledge, and reveal changes in their underlying beliefs and in the nature of their engagement.

Renninger and colleagues also measured change and engagement as they unfolded moment-to moment, focusing on collective collaboration outcomes while considering individual variations and different learning patterns. Studies in CC learning show that children progress along different pathways, with mental models and conceptual understanding varying significantly (Schneider & Hardy, 2013; Vosniadou & Brewer, 1992). Schneider and Hardy (2013), used latent profile transition analysis, to identify five developmental pathways in third-graders' understanding of floating and sinking, revealing how prior knowledge influences conceptual development. These findings highlight the importance of considering both qualitative and quantitative individual differences at specific measurement points, as well as changes over time (Hickendorff et al., 2018).

A microgenetic learning analysis perspective, commonly used in CC and developmental psychology, provides a fine-grained, moment-by-moment view of how engagement evolves. This method detects the small steps learners take throughout the learning process (Lee & Karmiloff-Smith, 2002, Parnafes & diSessa, 2013; Siegler, 2006). The focus is primarily on the child in real time, "understanding the child's planning, monitoring, self-repairs, and spontaneous comments, charting change as it occurred in the space of a single session" (Karmiloff-Smith, 2013, p.49).

For instance, regarding Renninger and colleagues' research, it would be intriguing to further investigate the specific thinking exhibited by each child and the group in different learning pathways that led to similar performance levels in the final phase of solving the mathematical problem. Are there qualitative differences, and where do individual and interindividual variations originate? Do these different pathways reveal different levels of understanding and metacognitive reflection? Do students engage similarly as they reflect on their initial beliefs and compare them with new concepts? Renninger and colleagues assessed both students' activity during problem-solving and their engagement modes. In the context of CC, it would also be beneficial to examine instances such as cognitive conflicts (e.g., states of disagreement, inconsistencies), analogical reasoning, argumentation type (e.g., negotiation of ideas, discussion of multiple views) and moments of reflection (e.g., self-awareness of CC) (Luebeck & Bice, 2005). These smaller, incremental, momentary changes could provide deeper insights into students' conceptual changes and help track their progress in knowledge construction.

The complex interaction among various factors should also be considered when measuring engagement. Learners' characteristics, emotional and motivational factors, pre-existing knowledge, epistemic beliefs, and interest in the specific problem situation all play a role. For example, Stathopoulou and Vosniadou (2007) interviewed two high-achieving physics students with similar grades but different approaches to learning. One demonstrated awareness of his beliefs and integrated new ideas with a meaning making orientation, while the other student was unaware of his beliefs and adopted superficial strategies, such as memorization, with a performance-orientated perspective. Their differing epistemic profiles - one with a constructivist, physics-related epistemology and the other with a less-constructivist epistemology- significantly influenced their engagement level. These issues will be further addressed in the second section of the paper and discussed through the prism of CC framework.

2.2 Theoretical Reflections: Modes of engagement measures

Another important aspect to consider is the quality and depth of engagement examined, which are linked to how active engagement is defined. For instance, a student might be behaviorally engaged but exhibit low interest or weak cognitive or metacognitive engagement (Chi & Wylie, 2014; Renninger & Bachrach, 2015). Identifying overt behavioral indicators of knowledge change processes is essential for assessing students' engagement during learning (Chi & Wylie, 2014).

In CC learning, simply being “active” may not be sufficient. Active behaviors range from merely doing something (e.g., manipulating, underlying, choosing a justification), to actually constructing knowledge, to collaborating in groups in a co-constructive mode (Chi & Wylie, 2014; Vosniadou et al., 2023). Chi and colleagues associate three distinct hierarchical modes -active, constructive, and interactive- with "active learning", each implying different underlying processes of knowledge change and resulting in progressively more effective learning (Chi et al., 2018; Chi & Wylie, 2014).

Conceptual change learning extends beyond simple "active learning" to include a "constructive learning" mode, involving activities such as drawing analogies, asking questions, comparing, self-explaining, reflecting and monitoring. These activities produce external outputs, such as hypotheses, predictions, and justifications, which introduce new ideas beyond the presented information leading to the creation of new knowledge (Chi & Wylie, 2014). Similarly, teachers’ observable behaviors, like scaffolding prompts, can further promote children's generativity.

Within this constructive mode, the focus is on the individual but can be further enhanced by an “interactive” mode of engagement between partners, which builds upon and encompasses the constructive mode. Chi (2021) emphasizes the concept of co-inference, where partners engage in mutual knowledge construction through dynamic exchanges, enhancing understanding by integrating each other’s contributions (Chi & Wylie, 2014). Many researchers assert that understanding is a social process, that also involves individual mental effort. Classroom pair activities should be analyzed for both shared understanding and the individual processing of differing perspectives (Inagaki et al., 1998; Miyake, 1986). Hatano and Inagaki (2013) suggest examining collective comprehension activity alongside individual outcomes, addressing both intermental and intramental processes.

The papers in this issue explore different modes of active learning and engagement. Symonds and colleagues observed students’ behavioral engagement, providing evidence of active engagement but not of constructive or interactive engagement. Although the presence or absence of cooperative behavior was recorded, further information about the type of cooperation between students or between students and teachers is not provided. Moreover, while a process of self-regulation (important process in constructive teaching) underlies behavioral engagement, it is not explicitly discussed in their paper. In Tang and colleagues’ study, students are actively engaged, but there is no explicit evidence of constructive or interactive engagement, as the focus was on situational feelings and experiences. Renninger and colleagues implicitly referred to a constructive-interactive mode of engagement highlighting elements such as the use of prior math knowledge, exploration, planning, awareness of multiple perspectives and self-regulation. Group cooperation in their study involves sharing new ideas, taking turns in participation, and engaging in discussions. Collaboration, in turn, involves shared understanding, negotiations, incorporating diverse viewpoints, and extending thinking. Haataja and colleagues’ study also includes aspects of the constructive-interactive mode, such as the co-construction of knowledge, co-regulation, and socially shared regulation of learning, where group members negotiate, reciprocally expressing perspectives and adapt to learning challenges. However, their study lacks a qualitative description of the various verbal exchanges during task execution. Additional information of individual engagement experiences within the group may be needed. The work of Baines and colleagues introduces another parameter: the role of peer relationships, particularly as expressed within the classroom context. Their study showed that measures of classroom peer relations were strongly associated with both observed behavioral engagement and classroom cognitive engagement. Indeed, being popular as a work partner or recognized as highly effective at group work, positively predicted both science achievement and increased progress over the year. This finding highlights the importance of examining peer relationships within the context of the co-constructive interactions discussed before. This underscores the importance of simultaneously exploring various factors to analyse the working partners' profile, detect potential developmental differences, and observe how the depth of engagement evolves over time based on the individuals' profiles.

Analysis of classroom observations should also include evaluating the types of activities designed by teachers to promote learning and engagement. Research reveals that teachers often adopt a transmissive approach to learning, frequently lacking explicit teaching theories (Lawson et al., 2023; Torsney & Symonds, 2019; Vosniadou et. al, 2023). Vosniadou and colleagues (2023) developed a coding guide to analyse lesson tasks based on the ICAP (Interactive-Constructive-Active-Passive) model of engagement (Chi, 2009; Chi et al., 2018; Chi & Wylie, 2014). Their findings indicate that most tasks promoted only active engagement, without fostering deeper constructive or interactive learning. Most whole-class discussions failed to engage students constructively, as they lacked elements such as critical reflection, comparisons between new and prior concepts, or the transfer of new knowledge across domains. Symonds and colleagues (this issue) observed higher levels of behavioral disengagement in larger classes with 22 or more students, emphasizing the importance of smaller pupil-teacher ratios. Smaller class sizes enable teachers to interact more effectively with students, which is an important prerequisite for CC learning. Lower ability was identified as a risk factor for disengagement in larger classrooms, but not in smaller ones. Additionally, smaller classrooms were shown to be particularly beneficial for children from privileged backgrounds, suggesting that class size has a greater impact than socioeconomic status alone. Similar studies indicate that students in small schools or those with a communal organization, where teachers create socially supportive and intellectually challenging environments, show higher levels of engagement (Fredricks et. al, 2004).

Inkinen and colleagues (2020) linked certain scientific practices in science teaching, such as developing models and constructing explanations, to optimal learning moments. These practices, central to CC, were linked to deeper situational engagement and were more likely to challenge students, thereby triggering their interest. Johnson and Sinatra (2013), drawing on the expectancy-value theory framework, demonstrated that perceived task utility enhances engagement by activating prior knowledge and focusing attention on relevant information, thereby supporting CC.

These findings underscore a significant challenge in educational contexts, particularly for CC learning. It is important to examine children's ME across various levels- individual, group, and task-related- while also considering teachers' beliefs system about learning and teaching. McNeill (2009) showed that teachers' conceptualization of scientific argumentation significantly affects students' support and instructional practices. Simplified inquiry approaches often lead to weaker learning gains in students' ability to develop scientific arguments and to explain phenomena using evidence and reasoning. Furthermore, alongside evaluating the engagement levels in task design, it is essential to consider the types of Self-Regulated Learning embedded in these tasks, i.e., how students can take control of and regulate their learning, processes that are stimulated by the different modes of engagement (Lawson et al., 2023).

3. Rethinking momentary engagement beyond traditional acquisition type of learning: the paradigm of conceptual change

The papers in this special issue discuss current models that aim to explain ME during the learning process, focusing primarily on traditional learning acquisition (e.g. Xin Tang et al., this issue). However, these models fall short in addressing the complexity of conceptual change learning. This raises an intriguing question: how can we extend these models beyond traditional learning acquisition to contexts involving CC?

Conceptual change, in domains like science and mathematics, requires deep engagement and intricate cognitive processes (Sinatra & Pintrich, 2003). Understanding the emergence and revision of students' conceptual frameworks also requires consideration of motivational processes (Linnenbrink & Pintrich, 2002). However, factors influencing engagement in CC – such as epistemic cognition, participation in scientific practices, misconceptions, emotional responses to specific topics, attitudes toward science, and considerations of gender and identity- differ from those influencing simpler knowledge enrichment (Sinatra, Heddy & Lombardi, 2015). Cordova and colleagues (2014), stress the importance of understanding how these factors interact to influence knowledge reconstruction. While motivational beliefs - such as self-efficacy beliefs and learning goals- are linked to cognitive engagement (Pintrich & Schragben, 1992), recent studies indicate that effective learning characteristics in varied learning contexts may not yield equivalent benefits in CC learning (Cordova et al., 2014. Pintrich et al., 1993. Sinatra et al., 2015).

For instance, high interest and high prior knowledge, which typically enhance traditional learning, may hinder CC learning (Dole & Sinatra, 1998). The challenge in CC lies in encouraging students to critically assess their initial naïve theories and acknowledge inconsistencies when exposed to scientific information. How can students be motivated and interested in a topic where they hold strong, preexisting beliefs? What stimuli can redirect attention to conflicting viewpoints? How do factors like prior knowledge and epistemic beliefs shape motivational and cognitive processes during task engagement?

3.1 Learners' characteristics (interest, skill, challenge) and Prior Knowledge

Assessing students' commitment, strength and coherence of their prior knowledge can predict engagement levels when radical CC is required (Dole & Sinatra, 1998; Jones et al., 2015). Strong prior knowledge, coupled with a high commitment to entrenched beliefs, reduce the likelihood of CC, particularly when combined with high topic interest (Dole & Sinatra, 1998; Murphy et al., 2005). Several researchers highlighted the importance of examining how interest interacts with other variables, such as epistemic beliefs and misconceptions, rather than studying it in isolation (Linnenbrink-Garcia et al., 2012; Murphy & Alexander, 2004). Cordova and colleagues (2014) found that students with high self-efficacy and interest but low prior scientific understanding were more likely to achieve CC than those with strong prior knowledge combined with high confidence and interest. Similarly, Mason and colleagues (2008) highlighted the influence of combining topic interest with epistemic beliefs about scientific knowledge (complex and evolving vs. simple and certain) and text type (refutational vs. traditional text) on CC outcomes.

Self-efficacy beliefs, reflecting a student's confidence in their ability to perform a specific task (skill component), can influence CC in opposing ways. High self-efficacy in learning can support CC by fostering confidence in engaging with challenging tasks, such as argumentation and experimentation (Pintrich et al., 1993; Sinatra, 2005). However, if self-efficacy reinforces confidence in pre-existing conceptions, it may hinder CC by fostering resistance to new ideas. Interventions like refutational texts can help engage students by challenging misconceptions and guiding them toward scientifically accepted concepts (Cordova et al., 2014; Mason et al., 2008).

3.2 Epistemic emotions and epistemic beliefs

Recent research brings in the discussion the role of epistemic emotions that arise when students encounter unexpected or incongruent information and pertain to ongoing knowledge-generating activities (Muis et al.,2015; Pekrun et al., 2017). Contradictory information can evoke surprise, leading to two distinct pathways. Firstly, it may trigger curiosity and situational interest, motivating students to actively seek resolution for the inconsistency and engage in a challenging task. On the other hand, confusion may emerge, leading to unsuccessful attempts of resolution, causing students to abandon both the proposition and the task altogether.

However, confusion can be beneficial for learning in some cases, particularly when students attempt to resolve it by evaluating its source, adapting their strategies and employing metacognitive monitoring to track their progress (D'Mello et al., 2014). In this case, confusion is associated with enhanced, deep metacognitive strategies, more sophisticated self-regulated learning abilities and critical thinking (Chevrier et al. 2019). However, this positive dimension is more commonly observed in adult learners (D’Mello & Graesser, 2012; Muis et al., 2015). Furthermore, students with constructivist epistemic beliefs, viewing knowledge as complex and evolving, tend to experience more positive epistemic emotions and engage in deep self-regulated learning (Chevrier et al., 2019; Muis et al., 2015). Muis and colleagues (2015) suggest that epistemic beliefs act as antecedents to epistemic emotions through appraisals of epistemic congruity, novelty and complexity and of the attainment of epistemic aims.

3.3 Detractors and Accelerants

The boundaries between detractors and accelerants in CC may not always be clear-cut. Various factors influence the extent and the way students engage. Interestingly, "negative" factors often perceived as detractors, can sometimes promote CC by encouraging deeper engagement and learning (Broughton et al., 2013). For example, students with initial epistemic beliefs may feel surprised or confused hen confronted with information that contradicts their prior knowledge, potentially leading to disengagement. However, students with more constructivist epistemic beliefs may respond to such contradictions differently. Negative emotions can foster deep engagement with message processing, while positive emotions may sometimes result in shallower engagement. Instructional strategies, such as group discussions and debates, can help transform negative emotions into opportunities for CC (Gregoire, 2003; Nadelson et al., 2018).

4. Can we argue about a multi-perspective approach to understanding momentary engagement?

In previous sections, I used the CC paradigm to discuss ME at the micro-level, focusing on students’ dynamic learning moments in real time. Understanding how micro-level factors -such as individual differences, learner characteristics, cognitive and motivational factors, socio-cultural influences, and classroom settings- shape engagement, and examining their interrelations, can provide a more comprehensive perspective on ME. Rather than simply identifying correlations, researchers should prioritize exploring how these factors interact in various configurations that may affect ME in diverse ways. For example, Fredricks and colleagues (2004) propose a pattern-centered analysis that could uncover different configurations of engagement types.

Potential variations across different types of learning should also be considered. At the micro-level, various factors may play distinct roles in CC learning compared to traditional learning. To better understand the interrelation between engagement and the dynamic processes underlying knowledge revision, researchers should account for variations within specific domains, such as the physical and social sciences, as well as for topics with differing levels of contradiction. In CC research, methods should evolve to assess not only the cognitive components of engagement but also its affective and behavioral components. In turn, the CC paradigm could help inform new perspectives and methodologies for analyzing learning.

At the meta-level, CC could contribute to reconceptualizing the concept of engagement itself. The papers in this issue emphasize the need for a fundamental shift in how we conceptualize ME. Previous research has often examined engagement components in isolation. Is this approach sufficient, or should ME reconsidered as a holistic, integrated construct? The five papers discussed advocate for a pluralistic approach, incorporating multiple theoretical frameworks to deepen our understanding of the complexities surrounding engagement.

From a meta-level perspective, a holistic view of ME conceptualizes it as a complex system of interdependent parts that co-act, rather than as a mere accumulation of isolated components. The dynamic systems approach supports this perspective, suggesting that new forms of ME emerge from shifts in the relationships between components, resulting to the system's qualitative development through self-organization (Lee & Karmiloff-Smith, 2002). Symonds and colleagues (Symonds et al., 2024) further reconceptualize ME as a complex, dynamic developmental system. This integrative view emphasizes the co-action of parts and their interactions with the whole, recognizing the dynamic nature of engagement and offering a more nuanced understanding of its structure and processes. Expanding this approach to other types of learning, Nadelson and colleagues (2018) introduced the Dynamic Model of CC (DMCC), which addresses all three aspects of engagement -cognitive, affective and behavioral- while acknowledging the contextual and situational nature of CC. This holistic model describes CC as a dynamic, non-linear and non-recursive process, characterized by multidirectional interactions sensitive to changes in emotions, behaviors, motivation and contextual factors. It thereby offer pathways for both engagement and disengagement. Although the DMCC warrants further empirical study, it presents a promising framework for examining engagement in the context of CC.

While a holistic view offers valuable insights, it also poses challenges. How is ME conceptualized across different theoretical frameworks, and what are its boundaries? What elements does ME truly encompass? How can existing models be expanded to integrate multiple perspectives coherently? Addressing these questions requires careful consideration of how different frameworks influence one another, as varying constructs and definitions may hinder conceptual clarity and consistency in measurement (Appleton et al., 2008).

Future research should also explore the implications of these perspectives for both research and educational practice. Translating these insights into practical applications can help educators support students more effectively. A holistic understanding of ME can guide the development of targeted interventions that address the sequential coaction of motivation, emotion, cognitive engagement and physical actions within a task, rather than focusing exclusively on broad measures of classroom and school engagement. Programs such as the Professional Student Program for Educational Resilience (PROSPER) by Torsney and Symonds (2019) exemplify this approach by enhancing ME through a focus on both personal and social resources, fostering resilience across physical, motivational, emotional, and cognitive dimensions. Evaluating holistic programs like PROSPER in comparison to those targeting specific engagement components is essential to bridging the gap between research and practice, facilitating the application of holistic engagement models in educational settings. Overall, a holistic, dynamic approach to ME deepens our understanding of its complexity and paves the way for educational practices that are responsive to students' diverse needs and learning contexts.

Keypoints

- Expand the examination of momentary engagement (ME) beyond traditional acquisition models to encompass conceptual change learning.
- Address the methodological challenges of capturing a moment-by-moment analysis of ME, considering its multidimensional nature.
- Investigate the complex interplay of factors such as prior knowledge, epistemic beliefs, emotions, and learner characteristics in shaping ME across different types of learning.
- Differentiate between various modes of active learning and the depth of student engagement.
- Advocate for a holistic approach to ME, discussing its challenges and implications for educational practices and interventions.

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