Theorizing and Measuring Collective Productive Disciplinary Engagement

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Abstract: This symposium aims to explore current research working toward conceptualizing and measuring productive disciplinary engagement (PDE) contextualized in diverse learning and project contexts. Disciplinary engagement is critical for fostering students' deep, integrated understanding of STEM content and disciplinary practices. However, there are significant challenges to reaching this engagement quality, with CSCL environments providing opportunities and supports for engagement, but also posing challenges. This symposium aims to account for recent developments, as presenters showcase rich range in exploring application of PDE in diverse domains, grade bands, and learning contexts. The presentations also showcase a range of methods to analyze PDE as collective, situated, cross-contextual, dynamic, and generative.

This symposium aims to explore current research working toward conceptualizing and measuring productive disciplinary engagement (PDE) contextualized in diverse learning and project contexts. This topic is particularly relevant for computer-supported collaborative learning with its focus on coordinating efforts to build shared knowledge with the use of technology support (Roschelle, 2013). Consistent with the theme of the conference, we consider the complex ecosystems of collaborative learning that are embedded within disciplinary ideas and practices. Disciplinary engagement is critical for fostering students' deep, integrated understanding of STEM content and disciplinary practices. Since the early days of reform-based curricula involving inquiry and problem solving, we have been aware that "sustaining the doing, supporting the learning" is necessary to reap the benefits of these challenging learning environments (Blumenfeld et al., 1991). That is, students need to engage in ways that translate their motivations into generative learning with benefits for a greater likelihood of transfer to subsequent educational and professional contexts. There are significant challenges to reaching this deep-level engagement, such as the necessity to coordinate joint activity during cognitively demanding tasks. CSCL environments provide opportunities and supports for engaging in these kinds of tasks, but can also pose challenges (Jeong & Hmelo-Silver, 2016).

We draw from Engle & Conant's (2002) definition of PDE as making collective intellectual progress related to core ideas and disciplinary practices during authentic tasks. PDE exemplifies developments in the learning sciences, including a situative view of engagement, as (1) negotiated and constructed in particular activity systems and (2) comprised of instructional opportunities that support and constrain engagement (Greeno, 2006).

This view of engagement significantly extends research which has been grounded in an individual difference paradigm and has been conceptualized as general sense making (e.g., Zimmerman, 1990). Thus, these developments advance engagement as embedded within domain-specific and disciplinary contexts, and central to and inseparable from learning (Gresalfi, et al., 2009). Here, the quality of collective persistence in the face of challenge, positive affect and interest in the ideas and doing of activity, and interpersonal interactions while making meaningful connections is central to what students come to understand; highlighting the various interdependencies of learning processes, a central aim of CSCL research.

Now 15 years after the introduction of PDE, this symposium aims to present the frontiers of the research and account for developments, as the presentations examine PDE in a range of CSCL environments. We strive to build on a literature which has been limited to a focus on definition within single and illustrative cases to broaden the analytic and empirical landscape. Toward that end, we bring together four research groups showcasing rich range in exploring application of PDE in diverse domains (science, mathematics, engineering, educational psychology), grade bands (middle school through University) and learning contexts (after school programs, inquiry and problem solving curricula, online CSCL, as well as across resources and contexts). The presentations also showcase a range of methods to analyze PDE as collective, situated, cross-contextual, dynamic, and generative. Each presenter will introduce their (1) guiding framework for theorizing collective PDE, as contextualized in particular tasks, domains, instructional settings and disciplinary practices; (2) observable indicators of disciplinary engagement in the collective; and (3) analytic foci, making explicit the affordances of rich analysis for understanding collective engagement. As called for in the CSCL 2019 theme, these varied efforts to foster and study PDE have been carried out in contexts that are intended to support embodied, enactive, extended, and/or embedded CSCL. First, Gresalfi and her colleagues investigate the role of design features, alongside teachers and peers as relational resources, for *jointly* fostering persistence in the face of challenge for children in a computer science camp. Second, Damşa and Palonen consider the interrelationships of engagement dimensions for within and between group interactions during software engineering courses. Using social network analysis alongside qualitative content analysis, they track the change in density and the nature of collaborative engagement, among dimensions, over time. Next, Rogat and colleagues showcase their theoretical framework instantiated in a rubric using quality ratings to examine five dimensions of PDE during collaborative group exchanges, to contrast two case groups during a common collaborative task across two time segments. Subsequently, Hickey and colleagues extend the PDE design framework to be inclusive of expansive framing, by which learners engage with conceptual and disciplinary material in terms of their own personal and cultural orientations within three different undergraduate and graduate online CSCL contexts. Finally, our discussant addresses how these papers have collectively advanced what we understand about PDE within CSCL contexts.

Same place, new rules: The joint accomplishment of engagement

Melissa Gresalfi, Amanda Bell, Corey Brady, and Lauren Vogelstein

We face a documented shortage of computer scientists. By 2024, 1.1 million jobs are predicted in computing fields (Lockard & Wolf, 2012), but in 2015, fewer than 17,000 people graduated with computer science-related degrees; of those, fewer than 3,000 were women. Just 7% of workers in computing in 2014 identified as Black and 7% as Hispanic (Beckhusen, 2016). Clearly, the challenge we face is not only to encourage more people to engage in computing, but also to ensure that the diversity of our community is reflected in the field. To address this challenge, many suggest introducing students to Computer Science (CS) well before college. However, bringing computational thinking (CT) into K-12 contexts comes with its own potential challenges. Without careful attention to pedagogy and design, we might ultimately teach computational thinking in schools in ways that exacerbate current trends, contributing to the same K-12 participation gaps in interest and identity that we see in other STEM related fields. Thus, it is imperative that we look to the lessons learned about designing for equitable participation in these other fields as we seek to understand how to connect CS to K-12 contexts.

Research on students' mathematics learning has demonstrated how different designs support different forms of knowing. These same studies have established that the patterns we associate with who is good at math and who wants to persist at mathematics is as much a function of the way mathematics is taught than of mathematics itself. This is not to say that the field of mathematics has solved the problem of participation—quite to the contrary (Martin, Gholson, & Leonard, 2010). However, when we look at classrooms that reorganize the teaching of mathematics so that engaging the discipline is more than remembering facts and answering questions quickly, we find that very different patterns in interest and engagement emerge (Boaler & Greeno, 2000; Boaler & Staples, 2008). In contrast, a fast-paced, competitive environment turns off many students from the discipline.

It would be easy for this very same scenario happening with respect to Computational Thinking as so much of CT content might reasonably be organized into a set of facts and rules to be taught and practiced.

However, CT also involves practices of design (Kafai, 2016) that requires the understanding and principled adaptation of underlying facts and rules. Teaching students a set of rules that can then be applied is the version of teaching that is popular (and largely unsuccessful) in math classrooms; teaching students a set of design practices that create a need for CT concepts is a version of teaching that is being explored, with success, in math classrooms.

This study seeks to better understand how to support rich engagement with CT through the design of activities that leverage programming as a means of enacting expressive visual displays and effects. We conceptualize engagement as a collective act between person and context, seen as an interplay between the affordances of a learning environment and whether and how students act on those affordances. In previous work (Gresalfi, 2015; Gresalfi & Barab, 2011) we distinguished between different forms of agency that primarily focus on following rules and procedures, from more productive disciplinary engagement (Engle & Conant, 2002), which we see as involving consequential engagement (considering the implications of disciplinary decisions) and critical engagement (using those consequences to make decisions about how to best solve problems). In prior work, we have focused on the role of tasks in supporting student engagement; here we expand that analysis by considering the role of other students in the broader activity system.

We focus on eight students from two classrooms who are enrolled in a week-long day camp and who work both individually and collectively using NetLogo (Wilensky, 1999) to design images and representations of their own choosing. Specifically, our goal is to explore: 1) How the design of particular activities supports student engagement with the practices of CT, and in particular, what forms of agency are supported through their design; and 2) How others in the room become resources for inspiration, influence, and assistance throughout the camp. We focus on four students who mostly sat together throughout the week to understand both individual trajectories of participation, and how those trajectories connected and supported one another.

Data for this analysis draw on screen captures of students' work, videotapes of whole class discussions, and transcripts of interviews conducted at the beginning and end of the camp. Our analysis began by looking for changes in student activity across the week, and then focused on specific types of episodes. We sought to understand: 1) the nature of students design work (for example, what seemed to launch an idea? What was the focus of their attention, such as aesthetics or functionality?); 2) what happened when students encountered a challenge; and 3) what seemed to sustain their engagement over long periods of time. In examining these episodes, we attended to the interaction among students' ideas, their use of the tools and resources provided in the programming environment, and feedback they received from the environment and from others in the class.

Findings from these case analyses suggest a coherence amongst the eight focal students in their persistence in the face of challenge, their willingness to ask and offer assistance to others, and their commitment to achieving aesthetic and representational goals. These involved a routine back and forth between exploring the affordances and possibilities of the NetLogo environment, setting a representational or expressive goal that connected to personal interest, and then making different modifications to both that ended with a satisfactory final product. Interviews with students made it clear that they found this kind of activity to be novel, enjoyable, and validating; they routinely contrasted the practices of the camp with those at school. Students expressed that such practices transformed their experience of problem solving: "'Cause usually, for me… if I make a mistake, people get onto me about it. And when you're kind of coding... …If you make a mistake, nobody's there to pressure you about it, honestly. I mean, if you make a mistake, you can go back and fix it, and then you can also have somebody help you…and that's nice." They also expressed that the camp repositioned their relationships with teachers and students: "the teachers are really nice to you. I didn't get along with many teachers before and now I do. So, it helped me get along with teachers better too. I'm not a bad kid."

Forms of collaborative engagement in software engineering education

Crina Damşa and Tuire Palonen

Whereas teaching and learning activities used to be guided by clearly defined, generally accepted knowledge and a structured curricula, today, learning entails a dynamic body of knowledge and constant efforts for accessing and making meaning of resources. In this rather complex landscape, students are expected to participate actively and engage in various ways with knowledge contents and various resources, with peers and/or knowledgeable others. Such engagement involves different layers, such as the epistemic (engagement with the knowledge of the domain), relational (engagement with people – peers, teachers, experts, etc.) and regulative, or procedural (Damşa, 2014; Kumpulainen, 2013). In software engineering, at *epistemic* level, research emphasizes the need for students to understand shifting conceptual knowledge and developing the capacity to apply technical skills fluently, challenges often addressed by exposing students to authentic projects for creating software products. At *social-relational* level, engagement implies taking initiative to connect to resources of both intellectual and digital-material, but also human nature. The learning and collaboration resources provided by the course/program, such as peer or teachers, is often complemented by expertise held by knowledgeable others or entities outside the course boundaries, such as (in the case of software engineering) programmers platforms, professional programmers and even clients. Finally, at *regulative* level, organizing, self-managing and sustaining own or groups' learning activities places a good deal of responsibility on students. Various studies have shown students' strategies but also challenges to manage collaborative work in general, and advanced co-creation practices especially (Järvelä et al., 2016). Considering the complexity engagement as a phenomenon, more research is needed to understand the nature of these processes, in order to generate pedagogical solutions that support and empower students in their learning.

The current study aimed to generate better understanding of: a) whether the characteristics of the students' epistemic and social network are indicative of engagement and b) what types of engagement characterizes the co-creation process. The expectation was that the social network characteristics are related to the co-creation process and the way students engage and contribute to it. Conceptually, this study builds on sociocultural perspectives to learning to conceptualize engagement as a process that involves learners' sustained and situated thought and action in relation to knowledge contents, social relations and digital-material resources. This process does not take place in a vacuum, but is framed by various aspects of the learning environment (tasks, resources, guidance, etc.), of the social environments (interactions, relations), time-space affordances and constraints, and the capacity of individual/group to assemble these elements (Markauskaite & Goodyear, 2017).

This study employed a design-based approach in a case context. Participants were twenty-three second-year media engineering international students (three female and twenty-one male, average age 23.4 years, SD 2.8) from a university of applied sciences in Finland enrolled in a major in Media Engineering. The *Media Design and Integration* course is a second year undergraduate course aiming to support students to understand the design process of different digital products, emphasizing their full lifecycle; course activities were eight lectures and eight laboratory meetings. A *collaborative task* (in groups of three to four) was designed together with the teacher and required the groups to design a digital prototype of a 're-use library'. The task was complemented by discussions about design methods, and facilitated through face-to-face meetings during lab sessions, online collaboration through wiki and a discussion platform, and access to various sources of information and experts.

Mixed methods, consisting of a combination of qualitative and quantitative methods, were employed for ensuring (data) triangulation. Seven groups were followed intensively. A pre- and post- *networking questionnaire* was applied to gather data on the knowledge and social networking practices of students, inside and outside the class community. *Individual interviews* enriched the perspective on the possible individual networks. Event sampling through *weekly diaries* was used to collect data about students' work and interactions outside laboratory sessions, while *audio-recording of all the group discussions* documented the groups actual verbal behaviours. The drafts and the final version of the shared product, i.e. drawings, sketches, pictures, final prototypes were also gathered. *Social network analysis* and *qualitative content analysis* (see Damşa, 2014) were applied, in which the characteristics of students' network and the indication of engagement and knowledge co-creation were examined in depth. The group products were scored using an evaluation instrument developed in collaboration with the teacher.

The preliminary findings show a rather low average density of the networks (especially of the knowledge network) in the pre-test, which indicate that collaborative engagement of epistemic kind was minimal at class level. The pooled two 'superdimensions': Knowledge network (Collaboration, Advice, Epistemic input) and Social network (Emotional support and Informal network) did not show a denser network in the post-test. It is confirmed by students in interviews that they received most advice and ideas from the teachers, or others, and less from peers in class; but that under way intensive collaborative engagement at epistemic level (i.e., exchange of ideas, elaboration and development) occurred within groups. The results concerning social interaction and are not as radical, although they seem to follow the same trend. By the end of the course, social interaction has moved from between-group-interaction to inside-group-interaction. The qualitative findings support the finding that a more intensive epistemic engagement is indicated in the preliminary phase of the collaborative project, when groups discussed various ideas and alternatives; it diminished towards the end, where division of labour occurred and the interaction was minimal. At relational and regulative level, higher level of engagement was identified in some individual students who managed the process of collaboration and the group sticking to the plan, although not in all groups. One of the reported challenges was the lack of experience with collaborative work and the need to find strategies on the way. This has led to a lower level of engagement from some group members.

This study indicates the variety in the way engagement can materialize, but also the challenges that can occur for students in this regard, even in a rather 'common' collaboration task. Further analyses and research is recommended to identify types of task design and appropriate guidance that can support students to understand the nature, strategies and benefits of engagement.

Examining group Productive Disciplinary Engagement

Toni Kempler Rogat, Britte Haugan Cheng, Anne Traynor, Temitope F. Adeoye, Andrea Gomoll, Cindy E. Hmelo-Silver, and Patrik Lundh

This project extends Engle and Conant's (2002) conceptualization of students' productive disciplinary engagement (PDE) by characterizing the shared, multifaceted, and dynamic nature of engagement in the context of collaborative groups. Specifically, this project developed a rubric for describing group PDE in STEM contexts, used to analyze video data and ultimately, as part of real-time classroom observation by researchers and practitioners. The purpose of this work is theoretical development (i.e., specifying this extended definition PDE), as well as methodological development, in order to document patterns of PDE in classroom activities, specifically those that integrate disciplinary content and practices in instruction.

This work draws from and extends two bodies of theoretical and empirical work. First, we draw from engagement research stemming from an individual difference paradigm that conceptualizes engagement as multi-faceted, reflective of students' classroom experience, and malleable in context (Fredricks, et al., 2004). A multifaceted conceptualization enables a systematic observation of the dimensions of engagement that make-up PDE, with an eventual goal of examining interrelations and patterns of student engagement towards PDE (i.e., trajectories). Second, we extend prior conceptualizations of PDE (Engle & Conant, 2002). We extend these two paradigms by 1) specifying PDE as a dynamic construct, evolving and devolving over time (Skinner & Pitzer, 2012) and 2) integrating situative perspectives of engagement (Hickey, 2003). Here, a situative view understands engagement as negotiated and constructed in activity systems comprised of instructional opportunities that support and constrain engagement, given curriculum materials, teacher scaffolds, tasks, and interactions among learners (Greeno, 2006). Because PDE reflects students' participation within the social contexts of classroom activity, we extend prior work by providing necessary theoretical specification and methodological approaches to enable a broader analytic focus that encompasses collaborative groups over time. Moreover, our focus on social and disciplinary engagement facets extends extant frameworks aligned with our focus on collaborative groups contextualized in STEM content and disciplinary practices. Here, we aimed to illustrate the affordances of this conceptualization and measurement of collaborative group PDE by examining the changing nature of student engagement with implications for PDE for two contrasting collaborative groups contextualized in the same curriculum, lesson, domain, and disciplinary context.

Opportunities for and measurement of group PDE are situated in joint collaborative activity. In our work, PDE is contextualized in collaborative tasks involving modeling, design, and argumentation in middle school math, science, and engineering. We draw on a rich corpus of video data collected in 4 projects where group work in these contexts was central to unit goals and what groups came to understand. The range in domain, disciplinary practices and curricular features (e.g., technology tools, scaffolds) has enriched our theoretical development efforts. Data presented here were collected as part of The Promoting Reasoning and Conceptual Change in Science (PRACCIS) project, which developed inquiry-based units to encourage students' scientific reasoning (Chinn et al., 2008). In PRACCIS, collaborative groups develop, evaluate, and revise explanatory models. The video data from the project include filmed class sessions covering three curricular units in two classes from each of four teachers. We present codes of video recordings of two groups collaborating in a lesson occurring later in the curriculum.

The developed rubric encompasses five engagement facets using 3-point quality indicators, these include: *Behavioral engagement* (on-task joint participation); *social engagement* (responsive, equitable coordination), *emotional engagement* (socio-emotional climate), *metacognitive engagement* (shared content, task and disciplinary regulation), and *disciplinary engagement* (integrated conceptual and disciplinary contributions on a larger consequential task), with high-level ratings assumed to promote PDE. The rubric includes a designation of group structure (i.e., pairs; full group), and task characteristics.

Using the developed rubric two coders coded 8 video clips (approximately five-minute segments of each of 2 student groups). Coders achieved inter-coder reliability of 68%, after discussing discrepant codes on 4 clips and then jointly the remaining 4 clips. Codes of the jointly coded 4 video clips are presented here to illustrate the rubric's affordances for studying the dynamic nature of engagement and potential for comparing groups. Analysis of this small set of illustrative codes is visual, based on the presented graphs.

As can be seen in Figure 1, patterns of engagement remain relatively stable across these two, consecutive video segments. Group A exhibits high levels of social and emotional engagement, but do not progress beyond minimal disciplinary engagement. This pattern is a counter-example to common intuition that more social cohesion among groups and positive, emotional engagement, are key contributors to PDE. Similarly, Group B, exhibits a higher form of disciplinary engagement in the second segment, despite the stable and more moderate nature of the other 4 dimensions of engagement, including, social and emotional engagement.

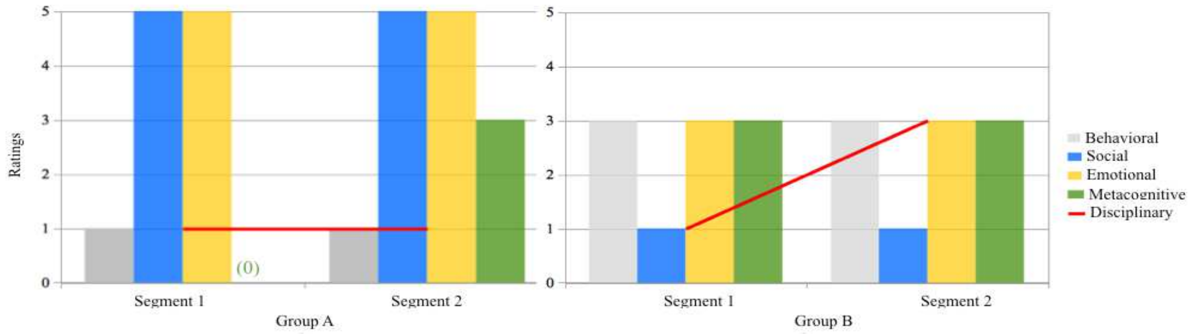

Figure 1. PDE codes of Group A and B across 2 consecutive segments.

This small, but illustrative data set highlights the ability of the new rubric to capture the temporal nature of group engagement in STEM practices and, more importantly, to identify patterns of engagement behaviors and their development. When used to code multiple segments of student collaboration, the rubric developed in this project has the potential to document rich patterns that can be examined, identifying how PDE evolves or is disrupted, as a function of group or task characteristics.

Expansive framing for equitable PDE in online CSCL contexts

Daniel Hickey, Christopher Andrews, Grant Chartrand, and Rebecca Itow

As illustrated by this symposium and other prior presentations and publications, Engle's notion of *productive disciplinary engagement* (PDE) has been embraced by some in the CSCL community. However, Engle's subsequent pedagogical framework for supporting PDE known as *expansive framing* (e.g., Engle, et al., 2012) has yet to be embraced by the by the CSCL community and has mostly been studied in conventional settings (e.g., Engle, et al., 2011). This presentation will summarize examples, tools, and findings from an extended program of research using expansive framing to support PDE in online CSCL contexts. This work shows that expansive framing is a relatively straightforward framework for supporting PDE and shows promise for equitably engaging diverse learners.

The presentation will first describe a template that has been used to support expansive framing in a range of collaborative online courses and has been extensively refined over the last decade. This template insistently frames disciplinary engagement using learner-generated events, places, people, and topics beyond those presented by course. Building on the work described in Hickey and Rehak (2013), this engagement is initially supported by a simple routine whereby learners publicly rank the relevance of carefully-curated elements of disciplinary knowledge and justify those rankings by drawing on their own professional, personal, and cultural orientations. This engagement occurs on commentable web-based pages (e.g., wikis or Google Docs) that are *public* to the class. These artifacts support collaborative *local* interaction (Hall & Rubin, 1998) via threaded discussions directly on those artifacts. Building on Gresalfi et al., (2009), this individual and social engagement are informally assessed with public reflections on four important aspects of PDE: *contextual, collaborative, consequential,* and *cultural* engagement. These reflections support PDE by (a) summatively assessing prior engagement, (b) proleptically motivating that engagement, and (c) formatively assessing disciplinary understanding. This disciplinary understanding is then formatively assessed via *private* self-assessments; where appropriate, disciplinary achievement is eventually summatively measured via *discreet* tests.

Examples and evidence from secondary, undergraduate, vocational, and graduate courses will be presented to illustrate three recent extensions of this program of research. The first extension is the addition of cultural engagement to the aforementioned reflections. This new reflection is intended to encourage learners to expansively frame their engagement in terms of their own personal and cultural orientations (Gutierrez & Rogoff, 2003). Analyses of prior courses suggested that organizing engagement primarily around professional orientation fostered inequities by privileging the engagement of more privileged learners from professional backgrounds and may have discouraged culturally-oriented critiques of disciplinary knowledge and practices. Analyses of several recent courses shows that this additional reflection fosters productive engagement in the intersection of disciplinary knowledge, disciplinary practice, and issues of power and privilege (e.g., Esmonde & Booker, 2017).

This engagement, in turn, supports important discussions of equity and justice that many learners might otherwise find uncomfortable.

The second extension of this program of research expansively frames collaborative engagement via web-based annotations of course readings using *Hypothes.is.* Students in an online undergraduate educational psychology course communally annotated 24 assigned readings using prompts that were intentionally worded to support expansive framing. Students' discourse in 460 threaded annotations were coded for enlistment of aspects of expansive framing (i.e., time, place, topic, participants, and accountability) and the degree to which those annotations were expansive. This confirmed that nearly every learner routinely enlisted most aspects (particularly topics and participants; accountability was notably less frequent) and showed that expansiveness of interactions was significantly correlated (r = .71) with performance on an open-ended exam that required learners to apply course topics to imagined teaching contexts. Interpretive qualitative analyses yielded evidence that expansively-framed interactions were indeed productive in that students made numerous connections between disciplinary knowledge and their nascent disciplinary practices. These connections are indicative of *generative* learning that will presumably transfer readily to subsequent educational, personal, and professional contexts. This study resulted in promising initial evidence that this straightforward method supported expansive framing in this context, and resulted in a coding scheme that should be useful for studying expansive framing in many contexts.

The third extension of this research is a new self-report survey of students' perceptions of their framing of engagement in both conventional and online courses. Building on Lam and colleagues (2014) and Zheng, et al. (in review), an initial set of items for each of the aspects of expansive framing were drafted and then refined in cognitive interviews with two subjects. The resulting set of items will be completed by at least 5,000 students in both conventional and fully online colleges as experimental items in the Spring 2019 administration of the National Survey of Student Engagement (NSSE; Kuh, 2003). This presentation will focus on exploratory and confirmatory factor analyses of the hypothesized aspects of expansive framing, demographic and institutional factors in framing, and correlations between aspects of expansive framing and other dimensions of student engagement captured by NSSE.

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