# Productive Disciplinary Engagement and Expansive Framing: Randi Engle's Situative Legacy

Daniel Thomas Hickey
*Indiana University*

**Abstract**

Productive disciplinary engagement (PDE) and expansive framing are two closely related frameworks for understanding and supporting education. These frameworks emerged from the research of the cognitive scientist Randi Engle (1967–2012) and colleagues. PDE was introduced in 2002 to describe a particularly noteworthy classroom discussion that was recorded in a reform-oriented elementary science classroom. PDE characterizes student engagement in the form of discourse that concerns the academic discipline at hand. Such disciplinary engagement is presumed to be productive when it asks disciplinary questions, clarifies disciplinary misunderstanding, and serves other functions that are known to support disciplinary learning. Engle and her co-author advanced a set of "guiding principles" for supporting PDE. These principles guide educators toward providing instruction and resources that help students (a) "problematize" disciplinary knowledge from their own perspectives; (b) accept a share of authority to resolve the disciplinary problems or questions that result; and (c) hold themselves and each other accountable for appropriately using the language and ideas of the discipline.

In 2006, Engle further explored the data from her 2002 study to consider how that learning had been "framed." She introduced the label "expansive framing" in an experimental study published in 2011 and further elaborated that theory in a paper published in 2012. Expansive framing offers additional educational principles for supporting PDE by helping teachers "position" students as authors (rather than consumers) of disciplinary knowledge. Expansive framing does this by insistently pushing each student to: (a) make connections with people, places, topics, and times beyond the boundaries of the assignment and/or course; and (b) see themselves as active participants in a broader intellectual conversation that extends over space and time.

Engle's characterization of engagement as PDE and the design principles for supporting PDE and expansive framing are some of the most useful guidelines for education to emerge from the theory of situated cognition that emerged in the 1980s. Situative theories of knowing and learning are less prescriptive for education than

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the behaviorist theories that dominated through the 1970s or the information processing and constructivist theories that became influential after the so-called "cognitive revolution" in the 1970s. Situative theories pay particular attention to the social and cultural contexts where learning takes place as well as the social and cultural contexts where that learning might later be used. This is what cognitive scientists call "transfer." Engle and others argue that PDE and expansive framing can support "generative" learning that transfers readily and widely to new contexts. This article reviews the most influential experimental and theoretical publications by Engle and colleagues regarding PDE and expansive framing and summarizes the research by others who have taken up these frameworks.

**Keywords:** Expansive framing; Productive disciplinary engagement; Situated cognition; Situativity; Transfer

## 1 Productive disciplinary engagement (PDE)

Randi Engle and Faith Conant introduced productive disciplinary engagement (PDE) in 2002 to explain a particularly compelling extended discussion that had been recorded in a 5th-grade environmental science classroom. This classroom was part of a study exploring the Community of Learners (CoL) instructional framework (Brown & Campione, 1994). The CoL framework was one of several influential frameworks that emerged in the early 1990s as cognitive psychology and educational psychology paid increased attention to the social and cultural aspects of learning (e.g., Cognition and Technology Group at Vanderbilt, 1990; Scardamalia & Bereiter, 1994). Engle and Conant's analyses used the theory of *situated cognition* (i.e., Greeno, 1998) that was a driving force in this trend in instruction. Most prior characterizations of student engagement (i.e., in the processes of learning) focused on cognitive associations and thinking processes. These prior studies had focused on the influence of individual factors like motivation (e.g., Corno & Mandinach, 1983) and goal orientation (e.g., Meece, Blumenfeld, & Hoyle, 1988) on *active* cognitive engagement. In contrast, PDE characterizes engagement primarily in terms of *discourse*. While this engagement is most obvious in classroom discussions, it can also take place as students interact independently with educational resources. From a PDE perspective, engagement means that students are making substantive contributions to discussions, coordinating their contributions with those of others, attending to others, demonstrating passion or emotion, staying engaged for long periods of time, and spontaneously re-engaging.

Regardless of its form, PDE refers to engagement that concerns the *discipline* at hand. For example, in their study, Engle and Conant examined how and why the students "made contact with both scholarly discourse in general and biology discourse in particular" (2002, p. 403). This designation was important because it downplayed the value of non-disciplinary engagement (for example general "thinking skills" like critical thinking, outside of any disciplinary context). Disciplinary engagement is presumed to be *productive* when students are making disciplinary claims that become more sophisticated over time, raising new questions, recognizing confusion, making new connections, satisfying goals, etc. By drawing on other like-minded researchers, Engle and Conant succeeded in defining a framework for characterizing and studying the primary outcomes of the larger class of educational reform efforts that had become prominent in the 1990s.

As Engle described it in a retrospective chapter published in 2011, the original inspiration for PDE came from what eventually came to be called "design-based research" (DBR). DBR

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aims to produce more general "design principles" in the context of efforts to transform everyday practices. Rather than controlling for variables in experimental studies, DBR refines design principles in complex, real-world settings. Consistent with this approach to educational research, a second important outcome of Engle and Conant's research was four "guiding principles" that they concluded were responsible for the PDE in their classroom and that others might adapt for use in other classrooms.

## 2 Guiding principles for fostering PDE

In their 2002 study, Engle and Conant drew on the ideas and conclusions of other researchers while carefully analyzing the video recordings and student work from their own data. This resulted in four "guiding principles" for fostering PDE: The first principle was *problematizing content*. This principle suggests that educators "should encourage students' questions, proposals, challenges, and other intellectual contributions, rather than expecting that students should simply assimilate facts, procedures, and other 'answers'" (2002: 404). With roots in the work of John Dewey in the early 1900s, problematizing is action (by individuals or groups) that generates "disciplinary uncertainties." However, those uncertainties must be genuinely problematic, central to the discipline, and "responsive" to each learner's interests and goals. Significantly, this principle does not embrace the "constructivist" ethos that learners should construct new knowledge via internal sense making and the process of "discovery learning" (e.g., Clements & Battista, 1990). Rather, the first PDE principle argues that learners should make sense of established disciplinary knowledge by problematizing it from their own perspective. Thus, rather than helping elementary students discover the measures of central tendency (i.e., mean, median, and mode) in sets of numbers, this principle would instead suggest that students should generate personally relevant contexts in which to explore the consequences of using each of the three measures (e.g., Gresalfi, Barab, Siyahhan, & Christensen, 2009).

The second principle for fostering PDE is *giving students authority*. This is about "students having an active role, or *agency*, in defining, addressing, and resolving such problems" (Engle & Conant, 2002, p. 404). Within the PDE framework, having this agency (i.e., intellectual authority) means that students are authoring new knowledge and serving as the "local expert" on the specific problems they are solving. This requires that lessons and classrooms be designed so that every student has the experience of knowing more about something important (to the class) than anyone else in the class. Thus, the elementary student who chooses to practice using measures of central tendency in the context of basketball statistics because he is a basketball fanatic will almost certainly know more about measures of central tendency *in that context* than anyone else in the class (likely including the teacher, unless the teacher is also a basketball fanatic).

The third PDE principle is *holding students accountable to others and to disciplinary norms*. This means that:

> the teacher and other members of the learning community foster students' responsibility for ensuring that their intellectual work is responsive to content and practices established by intellectual stakeholders inside and outside of their immediate learning environment, as well as to disciplinary norms.
>
> (Engle & Conant, 2002, p. 405)

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Engle and Conant recognized that the third principle would be challenging for many educators to implement. They acknowledged educators would need to use the principle "to the extent that [it] can be embodied in a classroom" (2002: 405). Engle explored the challenges of applying the third principle more directly in another study with Robert Faux in 2006. This study demonstrated an "inside out" strategy where students are gradually held more and more accountable by increasingly knowledgeable authorities. They showed that if students were first asked to hold themselves accountable, that would prepare students to be held accountable by "safe" peers (like in a small group). The small group experience would prepare students to be held accountable by more challenging peers (e.g., in a whole class presentation). The whole class experience would prepare students to be held accountable by "internal authorities" (like the teacher, perhaps in a formal evaluation of the presentation or during an exam). Finally, the scrutiny of the internal authority prepares students to be held accountable by an "external authority" (such as a visiting expert or during a field trip to a museum or zoo).

The fourth PDE principle, *providing relevant resources*, is at a more general level. The fourth principle reminds educators that students need extended time and relevant disciplinary resources to accomplish the goals of the first three principles. Of course, the nature and level of these resources depend on the content and the level of the students. Engle reminded educators that the quest for "authenticity" may lead to disciplinary resources that are too advanced to be used productively by their students. The important thing is balancing disciplinary rigor with students' ability to engage with those resources, alongside the supports that the teacher and the curriculum provide to help students use those resources. The practical nature of this framework is that the appropriateness of disciplinary resources (and the curricular routines for using them) can be evaluated and adjusted according to the amount of PDE that they appear to support.

## 3 PDE and framing as a framework for studying transfer

In 2006, Engle further analyzed data from the 2002 study to move the PDE framework more fully into the larger discussions about the *transfer* of learning. Transfer is one of the most important processes in education and one of the most debated topics among cognitive scientists. Transfer refers to the way that activity in one setting (the "learning context") affects activity in some later setting (the "transfer context"). In schools, transfer of learning is most obviously represented by the way that an earlier class prepares students to learn in a later class. This is an example of what Bransford and Schwartz (1999) called *preparation for future learning*. Most educators have encountered the experience of some students appearing to have little or no recollection of things that other students appeared to have learned in a previous class. But more generally, transfer research examines how learners (a) recognize the relevance of prior learning in the learning context and (b) and can use resulting learning in subsequent transfer contexts. In addition to classrooms, these transfer contexts can include personal lives, workplaces, and any other place that the prior learning might apply. While there is some debate, many scholars believe that transfer can be measured using educational assessments and some believe it can be approximated with achievement tests.

Engle (2006) used PDE to reframe the search for elusive *generative* school learning that transfers readily and widely to new settings, including settings that are very different from the learning environment. She argued that generative learning might be supported by considering how instruction was *framed*. Most previous studies of transfer had focused on the *content* (i.e.,

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the disciplinary knowledge) to be learned in the learning environment and then be used in the transfer environment. While some prior studies of transfer looked at the *context* of the learning and transfer environments, these studies had mostly looked at the *physical* features of the learning and transfer environments. Reflecting increased emphasis on social and cultural contexts in situative theories of learning, Engle expanded the consideration of content and context to consider *social* aspects of *both* content and context. As shown in Figure 1, she expanded the consideration of content by looking at how learners participated in the construction of disciplinary content during instruction. This expanded content analysis included two aspects. This first aspect (far left side of Figure 1) looked at how learners participated in the process of constructing content in discourse (by finding "common ground" with others). This was different from earlier transfer studies that assumed learners were constructing mental representations (i.e., of disciplinary examples and generalizations) that were then transferred. From a situative perspective, it was necessary to first consider whether knowledge of examples and generalizations were shared in the group before considering whether individuals in that group might transfer that knowledge to another setting. It is worth noting that this agreement need not be explicit, but rather normally draws on tacit signals that are part of being an effective communicator.

Engle (2006) further expanded the consideration of content in transfer by looking at the ways that individuals and disciplinary resources (e.g., texts) contributed to the construction of content over time. Her assumption was that some individuals may have participated in ways that might have better prepared them to use that content later and to do so without the help of others or the disciplinary resources. She looked at which students were more involved in the discussions, which students increased their involvement over time, etc. The 2006 study showed that individuals who participated more productively in constructing content over time were more able to use that content in subsequent settings. In this study, the transfer context was represented by a complex performance assessment featuring problems that were quite different from the problems that students worked on in class.

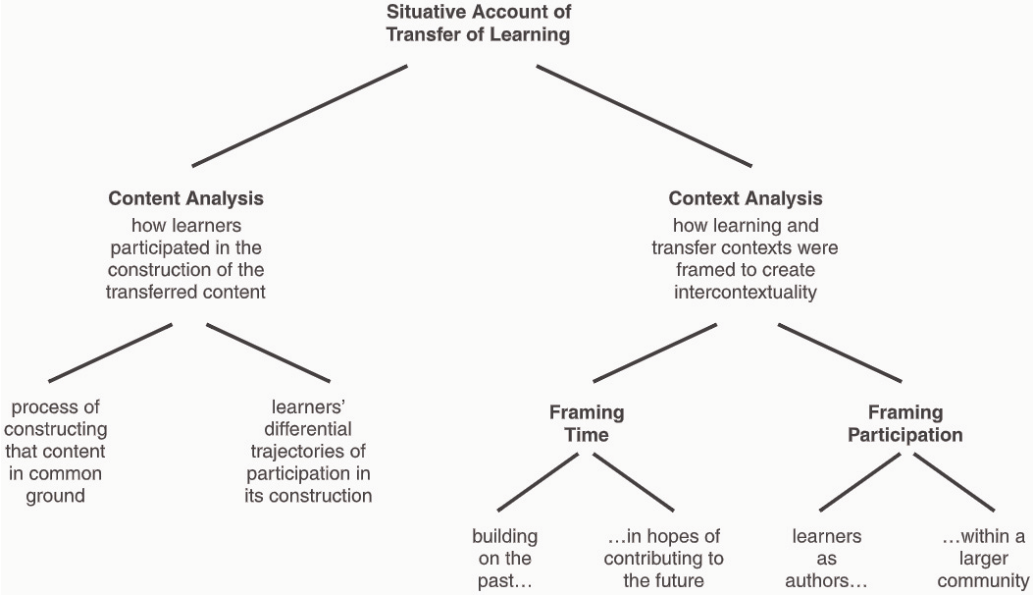


**Figure 1: An expanded situative account of transfer**

Source: From Engle (2006, used with permission)

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Engle's expanded theory of transfer in the 2006 analysis then considered the social aspects of the learning and transfer *contexts* (right side of Figure 1). She compared the social context of the learning setting to the social context of the transfer setting where the content was then used (or not). To reiterate, prior studies of transfer that considered contexts focused on physical contexts. To look at social contexts, Engle studied what others had called "intercontextuality." Intercontextuality occurs when the learning context becomes linked to prior relevant contexts and/or future transfer contexts. For example, if most of the students in one math class go on together to a subsequent math class, those students are more likely to transfer content from the first class to the second. This is because of the numerous connections between the participants in the two settings. This means that when constructing content (as described above) in the second class, the students would be able to call on shared memories of constructing common ground in the first class (e.g., "remember, that was the thing you forgot how to do over the holiday break"). Compare this to a student who just changed schools and takes this same second math class with these students. Without those many connections to the social context, that individual would have a harder time finding common ground and participating in the construction of content with new classmates who do not offer those connections.

Engle advanced two practical strategies for helping students create intercontextuality that should promote transfer (see Figure 1). The first involved *framing time*. This involved asking students to make references to (a) prior content learning that might be relevant and (b) to future contexts where students might use what they are learning. Rather than just discussing content in the immediate context where they are learning it, students are pushed to discuss how they (a) might have encountered that content in previous settings and (b) how they might use it in future settings. Engle argued that students are more likely to transfer their learning when they "come to understand that what they are currently doing is part of a larger intellectual conversation that extends across time" (2006, p. 457).

Engle's second strategy for helping students create intercontextuality involved *framing participation*. She argued that students should be framed (i.e., "positioned") by teachers and peers as *authors*. Like many of the educational reforms that were influenced by situative theories of learning, Engle was interested in reversing the tendency of schools to position students as "consumers" of content known to the teacher and presented in disciplinary resources. The importance of authorship is captured in the related term *authority*. Positioning students as authors creates expectations that those students will later be able to speak with authority about the knowledge that they previously authored. Rather than framing learning as private interactions among teachers, students, and resources, learning is framed as participation as an author in a larger intellectual conversation, as introduced in the previous paragraph.

While some readers might find the theory behind PDE to be complex, its practical implications are relatively straightforward. If educators want students to later use the ideas they are learning, students should *discuss* how they have encountered those ideas in the past and *discuss* how they might use them in the future. It is crucial that such framing involves discussion because it helps students benefit from the framing of their peers and allows students to learn from peers who might have more (or just different) experience or vision. In those discussions, teachers should position students as authors of new insights about those ideas, possibly by reminding them that they are the local experts about their own experiences and goals

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## 4 Use of the PDE framework and principles by others

Since their introduction in 2002, Engle and Conant's characterization of engagement and the guiding principles for fostering PDE have been widely taken up by others. In her retrospective 2011 chapter, Engle argued that PDE was a sufficiently general framework that others could adapt it to the content, culture, and discipline of other classrooms. That chapter identified 14 other widely cited efforts to reform mathematics or science instruction (many of which occurred before 2002) that had been described by others (i.e., not Engle) as being consistent with the PDE framework. This is important because it confirms the generalizability of the PDE framework for describing a much broader class of educational reform efforts. In Engle's words, "the PDE framework seems to capture some consensus ideas that are shared by members of our research community and are embodied in a wide variety of respected educational innovations" (2011, p. 176).

Other researchers have also used the PDE framework to study engagement naturalistically in classrooms. This included two of the four science education studies in a special section on PDE in a peer-reviewed international journal edited by Forman, Engle, Venturini, and Ford (2014). In one, Mortimer and de Araújo (2014) documented how the broader context of accountability and school culture obstructed a Brazilian high school chemistry teacher's efforts to support PDE; likewise, Venturini and Amade-Escot (2014) showed how a French physics teacher struggled to support PDE in light of curricular requirements and time constraints. In a subsequent study Koretsky, Vauras, Jones, Iiskala, and Volet (2019) studied three groups of collaborative STEM learners by documenting the extent to which their collaborative discourse embodied the four PDE design principles and documenting learning outcomes as indicated by the relative quality of their collaborative projects. They found that groups who engaged with conceptual tasks more deeply (as compared to taking up disciplinary practices) were less likely to engage in PDE-specific discursive practices. A comprehensive review by Hickey et al. (2021) uncovered over 100 peer-reviewed publications or dissertations using the PDE framework to study engagement. While these were mostly in science classrooms, some were in disciplines as diverse as gymnastics (Amade-Escot & Bennour, 2017). While most naturalistic studies of PDE have involved classroom learning, the framework has also been used to study learning in social networks (e.g., Borge, Ong, & Goggins, 2020) and online courses (e.g., Hickey, Quick, & Shen, 2015).

Engle's 2011 chapter went on to present a retrospective analysis of 27 specific interventions (20 led by other researchers and seven led by Engle) that implemented two or more of the PDE design principles. Engle's analysis of the 27 interventions examined (a) the extent to which each of the four PDE principles was embodied in each intervention (*strong, moderate, mixed, weak*, or *non-existent*) and (b) the extent that each of the three PDE-related outcomes (*productivity, disciplinarity*, and *engagement*) was observed (again, *strong, moderate, mixed, weak*, or *non-existent*). Looking across the 27 interventions, it was clear that the extent to which each of the four PDE principles was represented was directly related to the strength of each of the three PDE outcomes and vice versa. The findings suggested other relationships that made sense but warranted further study, such as weaker accountability appearing to be related to reduced engagement.

The review by Hickey et al. (2021) uncovered over 100 studies that use the PDE design principles to improve instruction. Most were in STEM contexts and most used interpretive methods to warrant using the principles and further refining them for specific instructional contexts. This included the other two articles in the aforementioned special section. In one,

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Meyer (2014) provided important evidence that students' "nascent" disciplinary frames became more expert over time; in the other, Forman and Ford (2014) showed how interpersonal (i.e., "social") accountability preceded and fostered intrapersonal (i.e., "individual") accountability. A similar use of both the framework and principles is represented by the extended program of design-based research into the development of material tools to support engagement in secondary environmental science classrooms by Nolen and colleagues (i.e., Nolen, Wetzstein, & Goodell, 2020; Vauras, Volet, & Nolen, 2019).

To reiterate, most of the studies of the PDE principles have been in science classrooms. But they have been used in other disciplines, including mathematics (e.g., Sengupta-Irving, 2016) and historical literacy (De La Paz et al., 2014). It is worth noting that all applications of the PDE principles involve relatively complex instructional content that lends itself to problematization; they would not make sense when applied to very specific factual content such as basic arithmetic. In terms of online learning, Hickey and Rehak (2013) embedded the PDE design principles within a broader learning and assessment framework in graduate education courses. Hickey and Uttamchandani (2017) showed how this framework could be scaled up to large "open" online courses. In these online settings, a relatively simple and scalable engagement routine has been used to help students problematize course content. Students are presented with "chunks" of content or sets of disciplinary resources. They are then asked to rank elements or resources in order of personal relevance and to provide a personalized rationale for that ranking.

Notably, relatively few studies of the PDE principles have included traditional empirical comparisons of PDE with different instructional approaches. Such studies are needed to generate the "effect sizes" that skeptics will likely need to be convinced. The aforementioned review uncovered just four studies that included comparisons studies that generated such effect sizes (i.e., Bradley & Conway, 2016; Engle, Nguyen, & Mendelson, 2011; Lachapelle, Jocz, & Phadnis, 2011; Weaver, 2019). However, readers might consider the arguments in Hammer, Gouvea, and Watkins (2018) that findings from comparing students in complex interventions are unlikely to generalize to other settings.

## 5 The introduction of expansive framing

Engle et al. (2011) revisited the design principles for supporting transfer and generative learning presented by Engle (2006). The revised principles were labeled *expansive framing* and were juxtaposed with a more restricted (i.e., decontextualized) *bounded* framing. The 2011 paper reported an experimental tutoring study that systematically compared transfer of learning from one-on-one tutoring sessions in human biology. Using scripts, half of the tutoring sessions (with Engle as the tutor) framed learning expansively by pushing learners to find connections with *settings* (*time, place*, and *participants*) and *topics* beyond the tutoring sessions. The expansively framed tutoring sessions positioned learners as *authors* of ideas and *respondents* to the instructional texts. Relative to typical classrooms, this positioning was individualized and rather insistent. In contrast, the scripts for the bounded tutoring sessions did not ask students to find connections with other settings, did not reference topics outside of the tutoring session, and positioned learners as "a spokesperson of a recipient for" (p. 611) the instructional texts. The 3–4-hour tutoring sessions on human cardiovascular systems were followed the next day by a 1–2-hour session that examined transfer of the prior learning of cardiovascular systems to human respiratory systems. Across four different carefully

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constructed transfer measures, the transfer of learning was shown to be dramatically larger in the expansively framed tutoring condition.

Engle, Lam, Meyer, and Nix (2012) further elaborated on expansive framing, juxtaposing it with conventional cognitive theories of transfer. In addition to two helpful illustrations, a noteworthy contribution was presented in five potential explanations for how expansive framing might promote transfer. The first explanation was that expansive framing should create *more intercontextuality between settings during learning.* Practically speaking, this means that it is crucial for teachers to help students make connections between the learning context and potential transfer contexts. Doing so leads students to expect that they will need to use what they are learning in future settings. This expectation encourages students to adopt more effective learning strategies that have long been associated with generative learning and knowledge transfer. The second closely related explanation concerns the way that such learners might later engage in subsequent transfer settings. If the initial learning was expansively framed (by using the strategies associated with the first explanation), the student is more likely to *recognize the relevance* of the learned content in the transfer context. If the students recognize the relevance of prior learning, they are more likely to decide to use it in the transfer context and more likely to be able to do so.

The third explanation of expansive framing in the 2012 paper concerns the synergy that should emerge when learning settings are connected with prior settings *and* students are positioned as authors of their own ideas. Doing so should lead students to *transfer in more of their prior knowledge*. This prior knowledge should transfer in for two reasons. The first reason is that students should see the relevance of the prior knowledge in the learning setting. The second reason is that students should recognize that the prior knowledge that they transfer in might be useful to others and is therefore socially desirable. This additional prior knowledge enables useful social learning processes such as comparing examples between students and identifying the most relevant examples.

The fourth explanation of expansive framing in the 2012 paper is that positioning students as authors is likely to *foster accountability to content*. This "ownership" of the knowledge gained in the learning context engenders confidence in using that knowledge in potential transfer contexts. Put differently, when students believe that they generated the disciplinary ideas in the learning setting, they are naturally more confident using that knowledge in the transfer setting. Conversely, if students were positioned as consumers of knowledge in the learning setting, they are likely to "defer" to the experts who generated the knowledge that they had consumed. The closely related fifth explanation is that positioning students as authors in the learning setting might generalize to transfer settings. Doing so should lead the students to *position themselves as authors in transfer settings.* In other words, multiple experiences authoring knowledge in learning settings are likely to result in a more general disposition toward authorship in all settings, independent of the relationship to the learning setting where they "became" an author. Rather than giving up in the face of hard problems, this authority should lead students to generate new knowledge, engage in more adaptive forms of problem-solving, and better adapt their prior knowledge.

In summary, Engle et al. (2012) advanced the following five explanations for why expansive framing of learning should enhance the transfer of that learning to subsequent settings:

1 Learners expect they will need to use what is being learned in connected settings, so they adopt more effective learning strategies.

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2 During potential transfer opportunities, learners view what was learned before as having continued relevance.
3 Learners view prior knowledge as both relevant for current learning and socially desirable.
4 Learners become publicly recognized as the author of transferable content.
5 Learners adopt practice of authoring knowledge and will both choose to and are able to author knowledge in transfer contexts more generally.

Significantly, the 2012 paper went on to provide detailed examples from multiple prior studies for each of these five explanations. These examples provided compelling initial evidence that these explanations were indeed valid pathways for expansively framed school learning to result in more generative learning that would likely be useful and used in subsequent transfer settings. The paper also briefly considered the potential interactions between the five explanations. Consider, for example, a student who recognizes the relevance of some prior knowledge in a learning context (Explanation 2, such as recalling a previous personal experience where the disciplinary content was relevant). A classmate might ask that student to explain that prior knowledge (e.g., "That seems like a really helpful example of X. Can you say more?"). In responding to that request, the first student is more likely to view that knowledge as socially desirable (Explanation 3). Furthermore, by being established as the author of that knowledge, the classmate might come to subsequently hold the first student accountable for the content that was shared (Explanation 4; e.g., "Does my use of X look right to you?").

## 6 Research designs for studying expansive framing

Engle et al. (2012) proposed three types of studies for investigating how framing affects transfer and for investigating the interactions described above. The first is *disentangling experiments* that manipulate specific aspects of framing contexts and study their independent contribution to transfer. Such a study might only manipulate the framing of setting (bounded vs. expansive) while controlling the framing of authorship (neither the expansive author nor the bounded spokesperson). A more ambitious study might consist of a 2 x 2 design where both setting and authorship are manipulated.

A second research design for studying expansive framing is *comparative classroom studies*. In a "within-teacher/between sections" design, this would involve the same educator teaching multiple sections of the same course, where one uses bounded framing and one uses expansive framing (akin to the tutoring experiment in Engle et al., 2011). In addition to examining any differences in existing learning outcomes, this would make it possible to use other measures (e.g., observations, survey instruments, interviews) that looked more closely at students' perceptions of their learning and the extent to which they reported that their learning in the expansive framing condition was indeed expansively framed.

Even without a comparison setting, Engle et al. (2012) point out that helpful insights might be gained by comparative classroom studies that employ a "within-teacher/between-student" design. These designs might use observations, surveys, and/or interviews to rank students according to how much they believed in or aligned with the idea of expansive framing (i.e., concepts are connected across settings and that they are authors, and perhaps both overall and according to the several aspects of expansive framing). These designs would also look at differences in transfer of those concepts according to course outcome measures, such as tests,

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performance assessments, appropriate use of concepts in essays or other artifacts, etc. Positive correlations between student alignment with expansive framing and transfer would provide initial evidence of the value of expansive framing. This evidence alone might be helpful in convincing skeptical educators of the value that expansive framing might add to their instruction. Lam, Mendelson, Meyer, and Goldwasser (2014) report one such study in a secondary biology classroom that documented increased transfer among students who both reported and demonstrated stronger alignment with expansive framing. Such studies could be particularly compelling if they controlled for other predictors of learning and transfer (e.g., prior grades, pretest scores, motivation, entrance exam scores, etc.). Engle, Lam, Meyer, and Nix (2012) further suggested that well-controlled correlational classroom studies might shed additional light on the relationships between specific aspects of framing and specific kinds of learning outcomes. This is most likely to be the case when there are a larger number of participants and the measure of expansive framing and the measures of learning and transfer are reliable.

The third type of study suggested by Engle et al. (2012) are *microgenetic investigations*. Such studies are common in the study of child development and focus directly on observing the hypothesized processes in action. Microgenetic investigation usually entail intensive videotaping and interviewing of students along with intensive analyses of student work in the learning setting and the transfer setting. Doing so can systematically trace (a) how the instructor framed learning, (b) how individual students took up that framing, (c) how that framing impacted each student's engagement with the content, and (d) how that engagement impacted transfer.

## 7 The use of expansive framing by others

While not as widely embraced as PDE, expansive framing has certainly been embraced by others beyond Engle and colleagues. As with PDE, this research has primarily taken place in STEM classrooms (e.g., Jordan, Gray, Brooks, Honwad, & Hmelo-Silver, 2013; Zuiker & Wright, 2015). However, the framework and principles have been applied in hybrid courses (e.g., Grover, Pea, & Cooper, 2015) and have been used in a comprehensive framework for online courses (Hickey, Chartrand, & Andrews, 2020). While the idea of helping students feel like authors is certainly not new, the expansive framing principles seem to provide a theoretically coherent framework for doing so, and for doing so in disciplines as diverse as history, biology, English, and cybersecurity (e.g., Hickey, Duncan, Gaylord, Hitchcock, Itow, & Stephens, 2020). The principles further point to the adjacent practices and scholarship such as *positioning theory* (Harré, Moghaddam, Cairnie, Rothbart, & Sabat, 2009). As with PDE, expansive framing has primarily been used in iterative design-based research and there are few comparison studies (e.g., Wright & Gotwals, 2017).

## 8 Critiques of PDE and expansive framing

Agarwal and Sengupta-Irving (2018, 2019) critiqued the PDE framework and (by extension) expansive framing from the perspective of broader concerns about deficit-based approaches to equitable education. They first conceded that the existing PDE principles might expand the participation of under-represented minority students, relative to traditional curricula. Specifically they agreed that (1) problematizing content allows for culturally meaningful explanation of that content, (2) granting authority to explore those problems gives students an

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active role in constructing knowledge, (3) holding students accountable ensures that authority comes with a justification that is open to critique, and (4) providing culturally relevant resources might tap into diverse students' interests. However, they questioned the extent to which this will occur for minoritized students, given the evidence that minoritized students are routinely "positioned out" of classroom discourse and/or positioned as lazy or disruptive by teachers and peers who are more advantaged and/or privileged.

Because of the way under-represented minorities get positioned out of classroom discourse and (therefore, presumably) achievement, Agarwal and Sengupta-Irving argued that implementing PDE while ignoring the realities of power and privilege limits the potential of the PDE principles for supporting equity. They argued that (1) problematizing content in ways that challenge culturally dominant ways of knowing can lead to racialized controversies, (2) supporting *intellectual* authority may ignore the potentially overwhelming power of *social* authority, (3) gaining authority to share and justify one's ideas is easier than maintaining accountability to critique and revise ideas, and (4) minoritized students may fail to connect disciplinary concepts with the majoritized racial and cultural meanings embedded in educational resources. These arguments also apply to Engle's ideas of expansive framing since framing itself involves implicit and explicit negotiations among people, about what is happening and how individuals are expected to participate.

In response to their concerns, Agarwal and Sengupta-Irving extended the four PDE principles with *repositioning*. This is where teachers "pay explicit attention to issues of power and positioning arising in the classroom interactions, and *reposition* students perceived as low status in order to provide and maintain access to their [disciplinary] discourse and participation" (2018, p. 835, emphasis in original). They introduced four new *Connective and Productive Disciplinary Engagement* (CPDE) principles for repositioning minoritized students: (1) use sociopolitical uncertainties to help problematize disciplinary knowledge; (2) curb undue social authority; (3) ensure equitable accountability; and (4) treat sociopolitical controversies as resources. Give how widely appreciated and used the PDE principles are, this critique and reframing is a promising development in long-running efforts to overcome inequity and systemic racism in educational practice and research.

## 9 Randi Engle's legacy

The biology education study reported in Lam et al. (2014) was the last program of research that Randi Engle was involved before her premature death. In her commentary on the aforementioned special issue, Kristiina Kumpulainen (2014) summarized five aspects of the "legacy of Productive Disciplinary Engagement." The first aspect is PDE's relevance for the so called "21st century" competencies such as critical thinking, problem solving, and communication whose importance has been elevated by our increased reliance on digital networks. Kumpulainen pointed out that the PDE articles in the special section (like most considerations of PDE) did not directly address this pervasive rhetoric of contemporary education. But she asserts that "it feels worthwhile to contextualize all this important work within this societal discourse" (2014, p. 216).

The second aspect of PDE's legacy that Kumpulainen recognized is the relatively general nature of the framework. Rather than a specific script which would likely be difficult for teachers to enact faithfully, PDE provides "guiding principles for both designing and understanding learning environments that seek to foster students' deep involvement and productive engagement in disciplinary work" (2014, p. 216).

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Kumpulainen's third aspect of PDE's legacy is that it is rooted in sociocultural theories of learning. Greeno (1998) and others have pointed out that situative/sociocultural theories of learning are not nearly as prescriptive for educational practice as the cognitive/constructivist and behavioral/empiricist that came before them. The PDE principles offer researchers and educators a manageable way of supporting the collective meaning making that is a central assumption of sociocultural theory:

> Collective meaning making requires that there is space for diverse expertise and interpretations that are open to challenge and reconsideration. From this perspective, expertise is seen as a dynamic entity that is distributed over the community – not only within the classroom but ideally also with authentic expert communities.
>
> (Kumpulainen, 2014, p. 217)

Kumpulainen points out that the PDE framework can accomplish this goal by expanding conventional learning practices, providing students with multiple diverse positions of authority, and helping students hold themselves and their peers accountable to the discourses of disciplines.

Kumpulainen's final aspect of PDE's legacy concerns the potential for future research. She calls on subsequent researchers to explore longitudinal studies that "illuminate the psychological, social, and cultural practices of learning communities over time" (2014, p. 219) and for research on PDE in other disciplines beyond science education. She also calls for more "participatory" research models that give more agency and voice to research subjects, and for more systematic reviews of the existing research. The embrace of both PDE as well as expansive framing in the research by others referenced above has continued after Engle's passing and are indeed part of PDE's legacy for educational research and practice.

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## References and further reading

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(An earlier version of their 2019 paper.)

Agarwal, P. & Sengupta-Irving, T. (2019) 'Integrating power to advance the study of connective and productive disciplinary engagement in mathematics and science', *Cognition and Instruction* 37(3): 349–366.
(Both of these articles critique the PDE framework for not explicitly addressing power and privilege and the way that minoritized students are often "positioned out" of classroom discourse. They offer revised versions of each of the four PDE principles that teachers can use to "reposition" the engagement of minoritized students.)

Amade-Escot, C. & Bennour, N. (2017) 'Productive disciplinary engagement within didactical transactions: A case study of student learning in gymnastics', *European Physical Education Review* 23: 279–296.
(Illustration of using the PDE framework to examine engagement in diverse disciplines.)

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(Presents a framework for creating and studying online learning communities using the PDE framework and design principles.)

Bradley, J. L. & Conway, P. F. (2016) 'A dual step transfer model: Sport and non-sport extracurricular activities and the enhancement of academic achievement', *British Educational Research Journal* 42: 703–728.
(Argues for a "dual step" model of transfer as a way of theorizing and studying the impact of extracurricular activities on academic achievement.)

Bransford, J. D. & Schwartz, D. L. (1999) 'Rethinking transfer: A simple proposal with multiple implications', *Review of Research in Education* 24(1): 61–100.
(An influential socio-constructivist framework for understanding and studying the transfer or learning.)

Brown, A. L. & Campione, J. C. (1994) *Guided discovery in a community of learners*, Cambridge, MA: MIT Press.
(Presents a detailed description of the ground-breaking Community of Learners instructional framework and multiple examples of its use.)

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(Presents additional analyses of the data first published in Engle and Conant (2002) and introduces the issue of framing as it relates to transfer.)

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(A retrospective chapter that summarizes research that explicitly or implicitly embraces the PDE framework and/or instructional design principles.)

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Engle, R. A. & Faux, R. B. (2006) 'Towards productive disciplinary engagement of prospective eachers in educational psychology: Comparing two methods of case-based instruction', *Teaching Educational Psychology* 1: 1–18.
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Engle, R. A., Nguyen, P. D., & Mendelson, A. (2011) 'The influence of framing on transfer: Initial evidence from a tutoring experiment', *Instructional Science* 39(5): 603–628.
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