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Expansive framing as pragmatic theory for online and hybrid instructional design

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Abstract
This article explores the complex question of how instruction should be *framed* (i.e., contextualized). Reports from the US National Research Council reveal a broad consensus among experts that most instruction should be framed with problems, examples, cases, and illustrations. Such framing is assumed to help learners connect new knowledge to broader "real world" knowledge, motivate continued engagement, and ensure that learners can transfer their new knowledge to subsequent contexts. However, different theories of learning lead to different assumptions about *when* such frames should be introduced and *how* such frames should be created. This article shows how contemporary situative theories of learning argue that frames should be (a) introduced before instructional content, (b) generated by learners themselves, (c) used to make connections with people, places, topics, and times beyond the boundaries of the course, and (d) used to position learners as authors who hold themselves and their peers accountable for their participation in disciplinary discourse. This *expansive* approach to framing promises to support engagement with disciplinary content that is productive (i.e., increasingly sophisticated, raising new questions, recognizing confusion, making new connections, etc.) and generative (i.e., supporting transferable learning that is likely to be useful and used in a wide range of subsequent educational, professional, achievement, and personal contexts). A framework called Participatory Learning and Assessment (PLA) is presented that embeds expansively framed engagement within multiple levels of increasing formal assessments. This paper first summarizes PLA as theory-laden design principles. It then presents PLA as fourteen more prescriptive steps that some may find easier to implement, allowing them to learn as they go. Examples are presented from several courses from an extended program of design-based research using this approach in online and hybrid secondary, undergraduate, graduate, and technical courses.

Keywords Online learning · Situative theory · Educational assessment · Instructional design · Participatory learning · Hybrid courses

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There is broad consensus among experts that most instruction should be *framed* (i.e., contextualized) with problems, examples, cases, and illustrations. This means that new skills and concepts should be connected to broader "real world" knowledge to help learners make sense of the new knowledge and to motivate continued engagement. This is presumed to help develop new knowledge in ways that are likely to transfer to subsequent educational, professional, achievement, and personal contexts. However, there is little consensus about how such framing should be carried out. Different theories of learning lead to different assumptions about *when* frames should be introduced (i.e., before vs. after the introduction of more specific instructional content). Different theories of learning also lead to different assumptions about *how* frames should be created (i.e., by subject matter experts/instructional designers/educators or by the learners themselves).

Drawing pragmatically from situative theories of learning, this article outlines an approach that we have been calling Participatory Learning and Assessment (PLA). At the core of PLA are the design principles that Engle, Lam, Meyer, and Nix (2012) advanced for *expansive framing*. These design principles have instructors and designers help learners generate their own frames and then help learners refine their frames as their disciplinary knowledge advances. This approach is likely new for many readers and might be counter-intuitive for some. But there is good reason and some evidence arguing that this approach will foster the most productive forms of engagement with disciplinary knowledge for many learners in many educational contexts. In contrast to prior cognitive characterizations of engagement focused on internal processes, *productive disciplinary engagement* (PDE; Engle and Conant 2002) focuses on increasingly sophisticated interactions, raises new questions and recognizes confusion within learners, and makes new connections among them. PDE has been shown to result in *generative* learning that transfers more readily to subsequent contexts. This kind of engagement appears useful for most instructional goals. PDE is assumed to be particularly relevant for learning the so-called "21st Century Skills" such as collaboration and communication.

This article first explains how this new approach to framing instruction is different from the way instruction is typically framed in the two approaches that follow from more well-known cognitive theories of learning. The article then summarizes the theoretical underpinnings of both PDE and expansive framing and the published research on both. It then summarizes an ongoing program of design-based research (DBR) that produced the PLA framework by embedding expansive framing for PDE within an innovative situative approach to formative and summative assessment. The article concludes by introducing new step-by-step guidelines for designing online instruction with PLA. Consistent with the theme of the special issue, this article does summarize the theory behind PLA. But it does so in a way that is intended to be coherent for educators and instructional designers who are not grounded in situative theories of learning. However, this new step-by-step presentation of PLA is intended for audiences who have little or no training in learning theory or instructional design. Specifically, we hope that designers and subject matter experts would be able to design instruction following these steps, and then come to appreciate the PLA design principles and their underlying theory while implementing or facilitating that instruction. In our experience, many instructional designers, instructors, and subject matter experts struggle to set aside "expert" mental models to focus instead on helping learners "try out" the discourses of the disciplines and "try on" expert identities. This presentation is intended to help such professionals learn to do so.

Consensus and disagreement on framing instruction

The US National Research Council (NRC) regularly brings together panels of internationally recognized experts to draft consensus reports regarding important scientifically-contested issues. One of the most widely cited of such reports was *How People Learn: Mind, Brain, & Experience*, which was released in 2000. Now referred to as "HPL I," the report acknowledged the importance of context in learning, designing curriculum, and organizing education:

> Learning is influenced in fundamental ways by the context in which it takes place. A community-centered approach requires the development of norms for the classroom and school, as well as connections to the outside world, that support core learning values (NRC 2000, p. 25).

A subsequent NRC report advanced the consensus that instruction targeting communication, collaborative problem solving, and other "21st Century" competencies needs to use "multiple and varied representations of concepts and tasks," "elaboration and questioning," and "examples and cases" (NRC 2012, pp. 9–10). This is what we mean by "framing." Just how this is done is the focus of this article.

The title and contents of the 2018 report, *How People Learn II: Learners, Contexts, and Cultures*, hints at the changing consensus across the first two decades of this century. The body of this second report presents a new consensus regarding the importance of social and cultural contexts of learning:

> What has become far clearer since *HPL I* was published is that every individual's learning is profoundly influenced by the particular context in which that person is situated. Researchers have been exploring how all learners grow and learn in culturally defined ways in culturally defined contexts (National Academy 2018, p. 22).

Such a theoretical consensus among experts has tremendous implications for learning design, research, and practice with instructional technologies (Ertmer and Newby 1993).

Despite this consensus around the importance of context, these reports are largely agnostic about just how context and culture should be taken into consideration in instructional design. Put differently, there is consensus that instruction and schooling should be framed with problems, examples, cases, and illustrations. But there is little consensus and open disagreement about when and how such framing should be carried out.

The longstanding debate over *when* instruction should be framed

One of the debates over framing concerns timing. This debate reflects enduring tensions within the broad class of what we characterize as "modern" cognitive theories of learning. One approach to the timing of framing follows from theories that are typically referred to as *information processing* or *associationist* theories (e.g., Anderson 1981). As the label "associationist" implies, these theories focus on the creation of associations between smaller elements of knowledge. In the extreme, some information processing theories assume that cognitive associations that have been mastered will transfer unproblematically to subsequent educational, professional, achievement, and personal contexts. While few theorists now recommend such extreme approaches, it still seems widely used. Extreme information processing approaches are particularly popular in introductory STEM courses, where students are often expected to master basic skills and facts in the abstract so that they can then be applied in more advanced courses.

But most instantiations of information processing theories agree with the National Research Council that some sort of framing of learning is needed in most educational settings:

> Most modern information-processing theories in cognitive psychology are "learning-by-doing," theories which imply that learning would occur best with a combination of abstract instruction and concrete illustrations of the lessons of this instruction (Anderson et al. 1996, p. 8).

These theories usually suggest that framing should be introduced after the mastery of more specific targeted concepts and skills, in order to minimize cognitive load (e.g., Moreno and Valdez 2005). This assumption has generated multiple instructional frameworks that have been validated by a wealth of empirical research. Among the most widely used models are *multimedia learning* (e.g., Mayer et al. 1995) and the *4C/ID* model (e.g., van Merriënboer et al. 2002).

A different approach to the timing of framing follows from another strand of cognitive theories that are variously referred to as *constructivist* (e.g., Glaser 1984), *social constructivist* (e.g., Kim 2001), and *constructionist* (e.g., Harel and Papert 1991). As implied by the labels, these theories emphasize *construction* rather than associations. These theories assume that learning primarily follows from the construction of more general mental schema via the process of making sense of new information. As such, these approaches tend to introduce frames much earlier, and then provide support and scaffolding to help learners construct understanding via inquiry and problem solving in those contexts. These assumptions have also generated various instructional frameworks that have been validated by a wealth of research. These include *anchored instruction* (e.g., Young 1994), *problem-based learning* (e.g., Hung 2011), *project-based learning* (e.g., Land and Greene 2000), and *inquiry-based learning* (e.g., Looi 1998).

Arguably, there are many other ways to characterize the difference between these two strands of learning theory and the instructional approaches that follow (see Kirschner et al. 2006 vs. Hmelo-Silver et al. 2007). But clearly the timing of framing via problems, examples, cases, and illustrations serves as a clear distinction between the two. Indeed, the more specific timing of framing is an important element of the empirical and theoretical research within both strands (e.g., compare van Merriënboer et al. 2003 with Evensen and Hmelo-Silver 2000).

In addition to the timing of framing, another difference is the different ways information processing and constructivist approaches support collaboration during learning. Some constructivist approaches (e.g., Cognition and Technology Group at Vanderbilt 1990) feature so much collaboration so early in learning that they have been characterized as "situated." In contrast, most information processing approaches introduce collaboration later in learning. These approaches generally treat collaboration as a more specific form of learning to be presented after individuals master the knowledge to be employed by using collaboration.

The newer question about *how* instruction should be framed

Most applications of information processing and constructivist approaches to instructional design embrace what can be characterized as *expert framing*. That is, instructional designers and educational technologists consult with disciplinary experts and/or experienced instructors to select or create the problems, examples, cases, and illustrations that they believe will best help learners develop expert mental models, motivate engagement, and facilitate transfer. Reflecting the increased appreciation of the importance of cultural contexts referenced above, both classes of approaches increasingly emphasize social learning goals and social aspects of larger real-world frames (e.g., Cognition and Technology Group at Vanderbilt 1990; Hmelo-Silver and Eberbach 2012; McLaren et al. 2011). We acknowledge that these approaches may result in frames that are personally relevant to some intended learners (and even most learners). As described next, there is still good reason to have learners generate their own frames.

A situative alternative to expert framing

In contrast to expert framing, some theorists argue that most instruction should be framed from *each learners' own perspective* towards the to-be-learned concepts. This perspective follows from a strand of cognitive psychology known as "situated cognition." These theories are most strongly associated with James Greeno and his collaborators and students (e.g., Greeno 1998, 2011; Greeno and Goldman 2013; Gresalfi et al. 2009; Hall and Rubin 2013). In particular, the late Randi Engle argued that each student should "problematize" new concepts from their own perspective regarding those concepts. Engle argued that doing so, while holding students accountable for participation in disciplinary norms, was ideal for fostering PDE (Engle and Conant 2002). More specifically, Engle and Conant (2002) advanced the following design principles for fostering PDE: (1) *problematize subject matter from the learner's perspective*, (2) *give learners authority to address the resulting problems*, (3) *hold learners accountable to others and to shared disciplinary norms*, and (4) *provide students with relevant resources for accomplishing these goals*.

The first PDE principle is the most important one and is a prerequisite for the second and third. The assumption behind the first principle is that each learner's perspective is unique and *by definition* different from an expert's perspective. PDE assumes that disciplinary engagement is "productive" when it builds numerous connections between disciplinary *knowledge* and disciplinary *practices.* Disciplinary knowledge is what experts "know" independent of context while disciplinary practices are what experts "do" in disciplinary contexts. A crucial difference between the two is that disciplinary knowledge is relatively easy to assess out of context. In contrast, disciplinary practices are typically recognized by other experts as they are carried out in disciplinary contexts and are quite difficult to assess using conventional educational assessments.

One concern with expert framing is that disciplinary practices that experts have simplified for learners may still be impossibly opaque for many learners. We believe this occurs in part because experts assume that the problems presented to learners must be "authentic" and "real world." In contrast, PDE pushes learners to connect disciplinary knowledge with their own "nascent" disciplinary practices, while interacting with other learners doing the same. Rather than authentic problems that are the embodiment of the real world for experts, Engle and Conant (2002, p. 404) suggested that "even seemingly closed issues can be opened up and problematized." Building on earlier work by Hiebert et al. (1996), they argued:

> Previously accepted facts can be treated as examinable claims, common explanatory accounts as needing evidence, and standard procedures as needing explanation for their functionality. Thus, problems do not need to be open from the perspective of experts in a discipline, but rather open from the perspective of students interpreting them, using *their available knowledge and resources* [emphasis added] (Engle and Conant 2002, p. 404).

PDE assumes that disciplinary problems must first be opened up in this fashion before learners can assume authority for solving those problems (Principal Two) and then be held accountable to others and for their participation in shared disciplinary norms (Principle Three). The key point here is that giving students agency over the way learning is framed empowers them. It does so by making them the local expert in the relationship between the disciplinary knowledge presented in the course and their own perspectives and experiences.

Since its introduction in 2002, PDE has been widely explored by researchers. Some of this research has taken a naturalistic approach and used PDE to help explain and extend our understanding of how learning occurs (e.g., Greeno 2011; Ma 2016; Meyer 2014; Stein et al. 2008; Venturini and Amade-Escot 2014; Gilbuena et al. 2014). Other interventionist research has explored how the PDE design principles can support generative learning (e.g., Heyd-Metzuyanim and Schwarz 2017; Kumpulainen 2014; Sengupta-Irving and Enyedy 2015; Alvarado et al. 2014; Manz 2018; Jasien and Horn 2018). While we failed to locate any published systematic reviews of research specifically on PDE, studies of PDE are included in a number of published reviews of this broader class of "discursive" models of instruction that draw from situative and sociocultural theories of learning (e.g., Cavagneto 2010; Duschl 2008; Manz 2015; Watkins 2005).

Situative theories of knowing and learning have been widely discussed in venues associated with educational technology and instructional design (e.g., Angeli 2008; Choi and Hannafin 1995; Henning 2013; Hay 1993; Herrington and Oliver 1999; Hung et al. 2004; McLellan 1996; Winn 1993; Young 1995). But the PDE design principles introduced above and related principles introduced below have yet to be taken up widely in these venues. A systematic search uncovered just a handful of references to PDE in instructional design and educational technology publications. These were Ertmer and Koehler (2014, 2018), Hickey and Rehak (2013), Leonard and Derry (2013), Gomoll et al. (2017), and McGrath (2004).

Advantages of a resolutely situative approach

As introduced above, some approaches that we characterize as "constructivist" include social elements that appear consistent with situative approaches. For complex reasons, we contend that approaches such as Anchored Instruction and more collaborative forms of Problem-Based Learning are more appropriately labeled "socio-constructivist." We believe that the resolutely situative approach we present here offers two distinct advantages over socio-constructivist approaches. The first advantage is found in Greeno's (1998) "situative synthesis." This refers to the way that a resolutely situative approach reframes individual activity in a way that reconciles differences between information processing and constructivist approaches. A resolutely situative approach reconciles these differences by treating both types of individual learning as "special cases" of socially situated activity. By granting primacy to social activity, a resolutely situative approach reframes mastery of smaller associations in expository learning *and* constructing schema while making sense of complex problems in constructivist learning as different types of learning that are both *primarily* social and only *secondarily* individual. This reconciliation is different than the "aggregative" approach to reconciliation between individual activity and social activity that is tacitly embraced by information processing, constructivist, and socio-constructivist theories.

This issue of reconciliation quickly exceeds our ambitions for this article. But in summary, aggregative reconciliation (a) uses information processing theories to consider very specific individual activity, (b) uses constructivist theories to explain higher order thinking, and (c) characterizes social activity by aggregating assumptions about individual activity (see Greeno et al. 1996, p. 40 for abbreviated discussions on this more common aggregative reconciliation and the situative "competitive" reconciliation). This distinction is important for the PLA framework because it justifies its embrace of multiple-choice achievement tests. Most constructivist and socio-constructivist frameworks characterize such assessments as inauthentic evidence of transfer (Barber et al. 2015; Pellegrino and Brophy 2008; Petrosino and Cunningham 2003; but see Hickey, Moore, & Pellegrino 2001). Our more resolutely situative approach treats multiple choice assessments as a "peculiar" (or perhaps even "bizarre") form of disciplinary discourse that nonetheless serves useful functions in many educational settings. Across Steps 9, 10, and 11, this reconciliation allows PLA to pragmatically embrace three different theories of learning to use three different types of assessment as evidence of transfer; in Step 7, this approach to reconciliation is also used to address the enduring debate over "extrinsic" rewards and "intrinsic" motivation.

The second advantage of a resolutely situative approach is that it promises to more effectively address issues of diversity, equity, and inclusion in education. We contend that framing instruction as much as possible using each learner's own social and cultural experiences will more effectively counter discriminatory "deficit-based" responses to diversity. Step 9 embraces a recent critique and extension of the PDE framework (Agarwal and Sengupta-Irving 2019). We believe that this offers a particularly promising way of using diversity among learners as an asset in the education of *all* learners (González et al. 2006; Lee 2003). This is not to say that information processing, constructivist, and socio-constructivist approaches do not and cannot address these concerns or are inherently deficit-based. Rather, we believe that using each learner's own experience to frame learning is a better starting point for countering deficit beliefs and using learner diversity as an asset to help overcome historical group-based inequities.

The potential of expansive framing for fostering PDE in online courses

To reiterate, PDE has been widely represented in the research literature outside of instructional design and educational technology venues. However, Engle's subsequent design principles for using *expansive framing* (e.g., as theorized in Engle et al. 2012) to support PDE have not been as widely embraced. Expansive framing provides additional practical design principles for fostering PDE. The first expansive framing design principle is that (1) *learners should be pushed to make connections with people, places, topics, and times beyond the defined boundaries of the course*. Doing so is intended to support the second principle (2) *help learners hold themselves and peers accountable for their participation in disciplinary discourse* and the third principle (3) *position learners as authors* (*rather than consumers*) *of disciplinary knowledge*.

We believe that the extension of expansive framing and PDE into online learning is particularly important. Most prior considerations of PDE and expansive framing have involved face-to-face learning. This learning has sometimes been mediated with technology, but usually has occurred in classrooms. Apart from Fasso and Knight (2015) and Mendelson (2010), a search of the published research literature failed to locate other studies of PDE or expansive framing in online course contexts beyond the research summarized here. We find this puzzling. This is because framing seems crucially important in online learning. Except for synchronous online formats, online curricular routines (and any framing) must be formalized in advance. As such, online instructors cannot frame course content "on-the-fly" in classroom discussions; doing so in asynchronous discussion forums is likely to be quite challenging.

The theory and research behind expansive framing

Expansive framing is intended to foster numerous *intercontextualities* (Bloome et al. 2009). It is these intercontextualities that result in more generative learning that transfers readily to other contexts. A modest but expanding pool of studies have shown that educators can learn to frame their instruction expansively and that doing so seems to result in more generative learning and transferable knowledge (e.g., Andrews et al. 2019; Becherer 2015; Chari et al. 2019; Engle et al. 2011a, b; Grover et al. 2015; Lam et al. 2014; Niosco 2016; Zheng et al. 2011/in revision; Zuiker and Wright 2015).

Additional support for using expansive framing to support generative learning and transferable knowledge is found in Lobato's (2003, 2012) studies of *actor-oriented transfer*. The point of both expansive framing and actor-oriented transfer is that connecting new knowledge as strongly as possible to each learners' own prior and (imagined) future experiences is expected to result in more generative learning, which is more likely to result in knowledge that is both useful *and* used in subsequent transfer contexts.

Expansive vs. expert vs. bounded framing

It is worth noting that prior considerations of expansive framing have juxtaposed it with "bounded" framing. This is where "contexts are narrowly defined as events within a single setting involving a restricted set of participants and topics, and in which learners do not play central intellectual roles" (Engle et al. 2011b, pp. 605–606). In our experience, many educators employ bounded framing, relating content to other concepts within a course, but not to external contexts or even other courses. To reiterate, this is arguably an extreme version of the information processing approach described above. Such bounded learning depends on the dubious assumption that newly-learned associations are easily retained and readily transferred to new contexts. However, bounded framing is not recommended by most learning experts and is particularly ill-suited for curricula and instructional designs intended to foster so-called "21st Century" competencies.

The prior comparisons with bounded framing served to illuminate the impact of specific aspects of expansive framing on knowledge transfer. For example, the study of expansive framing by tutoring carried out by Engle et al. (2011b) contrasted bounded framing with expansive framing of *settings* ("when," "where," and "who"), *topics* ("what"), and *roles* ("how"). In the bounded case, these references were all made back to the context of the lesson, while in the expansive case these references were all made to settings, topics, and roles beyond the lesson and/or course. While such comparisons were crucial for advancing theory, they seem biased in favor of expansive framing and did not advance the more pragmatic open questions about framing raised above. Therefore, this article and the program of research summarized here pragmatically juxtaposes expansive framing with the two versions of "expert" framing introduced above.

Emergence of the participatory learning and assessment framework

The Participatory Learning and Assessment (PLA) framework began emerging around 2007. At this time, the first author began teaching online courses and was awarded the first of several internal course development grants. The initial design of these new online courses drew directly from a decade of design-based assessment research. This research used situative theory to refine formative and summative assessments in multimedia, game-based, and participatory learning environments. As described elsewhere (Hickey et al. 2003, 2009, 2011), this prior research was carried out in collaboration with leading instructional innovators and attempted to confidently boost achievement without "teaching to the test." Learning in each of these programs of research was iteratively aligned across three levels of increasingly formal assessments: *close* informal classroom assessments oriented towards specific curricular activities, *proximal* semi-formal classroom assessments oriented towards broader curricular goals, and *distal* formal achievement tests oriented towards external educational standards.

As elaborated in Hickey (2015) and Hickey and Zuiker (2012), several aspects of this new "multi-level" assessment framework argue against widely held principles in the assessment community and may be counter-intuitive for some readers. As such, six elaborations are summarized here, along with the instructional implications that are elaborated in the last section of the paper. First, this assessment framework rejects the cognitivist caution against using one assessment for multiple purposes (because summative purposes usually undermine formative purposes; e.g., the NRC's [2001] *Knowing What Students Know* report; Pellegrino and Chudowsky 2003). Rather, the framework draws on situative theories of assessment (Gee 2003; Greeno and Gresalfi 2008) to focus on assessment *functions* rather than purposes (Hickey and Pellegrino 2005). Focusing on functions draws attention to both intended and unintended consequences and allows the same assessment to be used for multiple functions. When combined with a broader situative view of learning, this allows one assessment to concurrently serve both summative and formative functions.

Second, domain knowledge is represented more formally across multiple levels of assessment. This is in part because the learning that is assessed across levels is represented at increasingly lengthy *timescales* (Lemke 2000). Specifically, this means that learning that is captured at each assessment level takes place over longer and longer periods of time. This has implications for how assessment evidence is used to shape learning and to refine learning environments.

Third, this approach embraces Hall and Rubin's (2013) distinction between interactions that are *public* (directed at all participants in a class), *local* (directed at specific individuals in public), and *private* (directed to individuals in private). These distinctions have significant implications for maximizing the impact of instructor-student interaction, minimizing tedious mandatory peer interaction, and avoiding instructor "burnout."

Fourth, the iterative alignment of learning across assessment levels provides valid evidence for carrying out systematic design-based refinements of curricula and then documenting the ultimate impact of those refinements on distal standards-oriented tests. This use of three assessment levels minimizes what the validity theorist Messick (1995) labeled as *construct-construct-irrelevant easiness*. This "teaching to the test" occurs most frequently when summative assessments use items that are too similar to curricula and/or formative assessments. Likewise, this can also occur when formative assessments are too similar to the curriculum. In both cases, evidence of learning is artificially inflated.

Fifth, careful alignment across increasingly formal assessments increases the validity of evidence for designers. As elaborated in Hickey and Zuiker (2012), the presence or absence of "echoes" across assessment levels helps distinguish between systematic differences and random variance in design-based refinements. This is particularly important when conducting DBR in a single course with less than 30 learners, because of the increased influence of outliers and the corresponding limits on statistical power.

Finally, careful alignment across increasingly formal assessments increases the credibility of assessment results for learners. This removes some of the burden on instructors and facilitators for positioning (Anderson 2009) learner engagement so that it is both disciplinary and productive. This credibility also supports learners' self-regulation and supports student trust of assessment results. This, in turn, reduces corrosive discourse as students argue for higher scores or claim that well-constructed "best-answer" test items are somehow "unfair." Taken together, these factors may reduce or even eliminate a significant source of instructor burnout.

New synergy between PDE/expansive framing and multi-level assessment

As elaborated in Hickey (2011) and Hickey and Andrews (2018), PLA emerged in response to critiques of multi-level assessment by Lobato (2003) and the linguist James Gee. These critiques led us to embed the PDE principles into the multiple levels of assessment summarized above. Specifically, Engle and Conant's (2002) design principles inspired the design of public (to the class) engagement routines. These routines foster PDE using "wikifolios" featuring public threaded comments directly on student work (introduced in Hickey and Soylu 2012; Hickey and Rehak 2013). These new routines were embedded within the three levels of assessment and were subsequently further refined using the design principles for expansive framing in Engle et al. (2012). As shown in Table 1, PDE and expansive framing were represented by the first two PLA design principles. We believe that the synergy between PDE/expansive framing and multi-level assessment are the primary theoretical and practical contributions of the PLA framework for online educators and instructional designers. This synergy has been elaborated elsewhere (Hickey and Rehak 2013; Hickey 2015). As such we only provide a summary of the synergy between these two sets of design principles to help readers appreciate the corresponding steps in the final section of the paper.

Grade artifacts through local reflections

The most important synergy in the new PLA framework is that online instructors/facilitators can use informal close-level assessments to assess (and therefore grade) PDE in expansively framed online learning routines. This is accomplished using informal reflections that students place directly on their completed wikifolios. These student interactions are local

Table 1 Participatory Learning and Assessment (PLA) design principles and new steps

PLA design principle	Description	Source	Step in new PLA framework
1. Use public contexts to give meaning to knowledge tools	Learners define personalized framing context	1st PDE Principle	1. Create a personalized framing activity
	Learners use course concepts to solve problems and make connections with outside people, places, topics and times	2nd PDE principle and 1st expansive framing principles	2. Define an introductory engagement routine 3. Define primary engagement routines 4. Define secondary engagement routines 5. Define collaborative engagement routines (optional) 6. Define arbitrary engagement routines (as needed)
2. Reward productive disciplinary engagement	Students function as authors of knowledge, and hold selves and peers accountable to disciplinary norms and interact with peers doing the same	3rd PDE principle and 2nd expansive framing principle	7. Define student engagement routines and expectations
	Instructor provides public feedback that recognizes and rewards PDE		8. Define instructor engagement routines and expectations
3. Grade artifacts through local reflections	Students complete public reflections on engagement for each assignment and instructor uses them to efficiently grade student work	1st (close) level in multi-level assessment	9. Create public informal assessments of engagement
4. Let individuals assess their understanding privately	Students complete private self-assessments of their understanding on each assignment	2nd (proximal) level in multi-level assessment	10. Create private semi-formal self-assessments of understanding
5. Measure achievement discreetly	Students complete time-limited multiple-choice achievement tests for modules of assignments	3rd (distal) level in multi-level assessment	11. Create automated formal tests of achievement
		Practical experience using PLA	12. Create model wikifolos, podcasts, or videos (optional) 13. Create microcredentials (optional) 14. Design homepage, submission, and grading systems

in that they are made in the public where all members of the class can view them (and any corresponding instructor comments). But these local reflections are directed to the instructor as evidence of engagement. This means that (a) instructors can publicly comment on those reflections to help highlight and encourage PDE, (b) peers can read and comment on those reflections and instructor comments, and (c) instructors can use the reflections to efficiently assess prior engagement and privately assign points/grade and (as needed) provide constructive private feedback.

The reflections are intended to summatively assess PDE while formatively assessing students' conceptual understanding. This understanding concerns both disciplinary knowledge and the many relationships of that knowledge with nascent disciplinary practices of students and their peers. But the formative function of these reflections for PDE have implications that exceed prevailing constructivist views of formative assessment (e.g., Black and Wiliam 1998). In situative terms, the reflections are intended to shape student engagement *proleptically* (Cole 1996) whereby anticipation of the future shapes present activity. Specifically, anticipation of having to complete the reflections is expected to (a) encourage PDE and create more intercontextualities between disciplinary knowledge and nascent disciplinary practices, (b) support expansive framing by finding additional connections beyond the course, (c) encourage social interactions between the instructor and peers, (d) push the students to engage more and more deeply with the course concepts in the proximal formative self-assessments, and (e) further shape learner identities as the local expert regarding course content in their real or imagined expansively framed context.

Let individuals assess their understanding privately

The second important synergy in the PLA framework is the way that proximal self-assessments help motivate prior PDE while formatively assessing achievement. This is accomplished using self-assessments that feature "known-answer" open-ended items or performance tasks. By presenting such assessments privately, these assessments support accountability goals for disciplinary knowledge without undermining PDE in the assigments or reflections. Put differently, the private self-assessments "protect" the public discourse from known-answer questions (which undermine participation in disciplinary discourse when students withdraw out of concern that they don't know the answer; Cazden 1981).

Letting students self-assess their understanding gets educators out of the laborious task of providing individualized private formative feedback on relatively narrow representations of disciplinary knowledge. This addresses the "conundrum" of formative assessment (Hickey 2015) whereby the time that students and (particularly) instructors invest in formative assessment necessarily cuts into time spent engaging in other potentially more productive forms of disciplinary engagement. Put differently, we believe that engaging in public discussion threads on student work is a better use of precious instructor time than providing private feedback on formative assessments.

At a general level, our approach concurs with Bennett's (2011) concerns over the "educational urban legend" of formative assessment. From a situative perspective, the formalization (i.e., decontextualization) of disciplinary knowledge needed to create known-answer problems whose answers can be more or less "correct" is problematic. This is because doing so constrains the formative value of the learning that feedback can foster. In this regard, the PLA framework is quite different from the popular "backward design" model

(Wiggins and McTighe 2005) where curricular design works back from complex performance assessment tasks.

Measure achievement discreetly

This final design principle in the PLA framework concerns distal achievement tests and the validity of the scores they produce. Evidential validity is obtained by not allowing the curriculum or formative assessments to directly expose learners to the specific associations that make up the test items. By using efficient multiple-choice items, such tests can include enough items to provide a valid estimate of each learner's mastery of the disciplinary knowledge represented by a larger module of instruction. This is the "construct" of "achievement" in conventional measurement terms. Here we extend Hall and Rubin's (2013) notion of "private" interaction to add the notion of "discreet" interaction with achievement tests. In this way, PLA highlights that distal tests should not be emphasized in designing or delivering online courses. Of course, such tests must be well-constructed and protected from compromise. We believe that if they are, these tests can provide valid estimates of the extent to which disciplinary knowledge will transfer to subsequent educational, professional, achievement, and personal contexts. Such tests are easily deployed in modern learning management systems or Google tools, can be automatically and immediately scored, and require no instructor time.

Prior implementations of the PLA design principles

As detailed in Hickey and Rehak (2013), the PLA framework initially emerged within iterative refinements of two fully online graduate courses designed and taught by the first author: *Assessment in Schools* and *Learning and Cognition in Education.* The author has continued to teach the first course annually and it remains the primary site for implementing new features and refining existing ones. The second course has been taught successfully by adjuncts and graduate students perhaps a dozen times. The framework has since been successfully adapted and used by several other adjuncts to design and teach new graduate education courses, and in the design of four fully online self-paced online courses for K12 network analysts (e.g., K12 Cybersecurity, Hickey & Stephens, in preparation). A variation of PLA was also used in a social annotation activity in an undergraduate educational psychology course taught by the third author (Andrews et al. 2019).

The strongest evidence supporting the PLA framework came from a Google-funded effort to offer Assessment in Schools as a big (but not massive) open online course, or "BOOC." Coding of comment threads showed that even non-credit "open" learners were framing their learning expansively in ways that were both productive and disciplinary. This engagement led to impressive performance on time-limited multiple-choice achievement tests, while keeping the instructor workload manageable (Hickey et al. 2014, 2015; Hickey and Uttamchandani 2017). However, an extended research-practice partnership to implement PLA with a subset of teachers at a fully online university-run high school encountered mixed results. As documented in the resulting dissertation (Itow 2018), two educators (in English Language Arts and Social Studies) whose professional development coursework had included training in sociocultural theories of learning were able to adapt the PLA design principles to new online courses. Those courses are continuing to be delivered.

Initial analyses confirm that student engagement in these courses appears to be (a) almost entirely disciplinary, (b) mostly productive, and (c) mostly expansively framed. However, a biology teacher whose professional development included only traditional cognitive theories of learning was able to include only some aspects and elements. While engagement in this course also appears mostly disciplinary and productive, there appears to be fewer examples of expansive framing. Moreover, a mathematics teacher at that same online high school whose professional development included very little learning theory was unable to implement any elements of the PLA framework. Similarly, while pilot studies in hybrid secondary algebra courses and undergraduate mathematics courses for non-math majors seemed promising from our perspective (Uttamchandani et al. 2016), most of these instructors and some of the students did not see sufficient value-added to go beyond the pilot stage.

A new stepwise presentation of participatory learning and assessment

The remainder of this paper is our response to the findings in prior implementations and an effort to appeal to a broader audience. We have transformed the PLA design principles into more specific prescriptive steps for designing online and hybrid courses and added an additional step that recognizes the limitations of expansive framing. Table 1 depicts how each of these new steps follow generally from the PLA principles. This stepwise approach is intended to illustrate, as clearly as possible, how the theories summarized above can be pragmatically employed when designing online and hybrid courses. More specifically, these steps are intended to allow designers and educators to learn how this new approach to learning and assessment functions *while* designing and implementing engagement routines and assessments. It will draw examples primarily from the ongoing courses such as Assessment in Schools and secondary biology courses.

Step 1: create a personalized framing activity

This activity is intended to help learners define a personally relevant context in which to practice using the "conceptual tools" of the discipline of the course. To the extent possible, this frame is intended to draw on each learners' own prior experiences, current aspirations, and future goals. Designing this crucial activity is relatively straightforward in professional courses. This is because learners come to such courses with clearly defined contexts or can easily imagine a relevant context. For example, in Assessment in Schools, students define a curricular aim that they have or might teach towards. Likewise, in the K12 network analyst course, learners are asked to describe a computer network that they already work with or would like to work with.

In non-professional and pre-professional courses, more structure may be needed for the framing activity. In the ongoing biology course, each assignment is framed separately, as described later in Step 6. In a pilot with undergraduate mathematics, non-math majors framed their initial engagement with mathematical content standards by drawing on their majors (Uttamchandani et al. 2016). In an ongoing secondary history course, students are offered a list of eleven different historical frames (e.g., economic, political, military, etc.) from which to engage (Itow 2018). In a hybrid undergraduate cinema theory course, students were asked to embrace one of seven directorial roles (e.g., sound director, lighting director, etc.; Walsh and Hickey 2012–2013).

It is important here to distinguish between these more structured versions of expansive framing and expert framing described above. While these structured frames have indeed been defined and/or selected by experts, significant attention is directed to helping students (a) select personally relevant frames, (b) gain unique expertise regarding the intersection of that frame and course content, and (c) refine their knowledge of that frame across assignments as their disciplinary knowledge grows. Students should be reminded that (a) some first drafts of framing contexts will be incomplete or even inappropriate, (b) they can and should look at peer examples, and (c) that they can adapt or change their framing context as needed.

In our experience, skeptics have worried that less-experienced learners would generate frames that experts would consider incorrect or inappropriate. As elaborated by Lobato (2012), it is crucial to recognize that the nascent disciplinary practices represent the learner's relatively naïve perspective, rather than a simplified version of an expert's perspective. Put differently, it is not necessary that each learner's initial framing context be "appropriate" or "correct" from an expert perspective. Rather, the initial frames only need to support engagement in the initial routines. Of course, we share the concern with skeptics that students might leave courses with incomplete or inaccurate knowledge of disciplinary practices. Once learners have made sense of disciplinary knowledge (by connecting it with their own nascent disciplinary practices), they are better prepared to learn to use that knowledge more appropriately within more expert practices. More specifically, we believe that such expert practices are gained most efficiently by (a) starting from each learner's own relevant experience, interests, and goals, (b) using instructor public feedback, instructional resources, and peer interaction to reframe those practices more appropriately, and (c) relying on formative and summative assessments to ensure expert knowledge. We further assume that the highly contextual disciplinary practices are more readily adapted when learners transfer their more static disciplinary knowledge to subsequent transfer contexts. We recognize that this is ultimately an empirical question and have been actively seeking support for the careful and extended program of research needed to resolve this question (e.g., Hickey et al. 2019).

Step 2: define an introductory engagement routine

This initial introductory routine introduces PDE with relatively simple course content. In most of our courses, this is accomplished in the very first wikifolio assignment (sometimes before students define their framing context following Step 1). For example, in the Assessment in Schools course, the very first assignment has students introduce themselves to their classmates on their wikifolio homepage by explaining what role assessment plays in their job and beyond. Students are then instructed to generate a wikifolio page, insert a header on their new page, and indicate which of three *Reasons for Today's Teachers to Know about Assessment* (introduced in the first chapter of the assigned textbook) was most relevant to them *and why*. This provides a very basic introduction to the "relevance ranking" routine that they will use in most subsequent assignments. In other courses, students have been asked to introduce themselves to their peers by indicating which of the course learning outcomes they expect to be most relevant to their educational or career goals. Put differently, students are typically asked to introduce themselves at the beginning of online courses; we suggest that they be introduced to expansive framing when doing so while also introducing them to course content.

Step 3: define primary engagement routines

These routines diverge from traditional curricular routines because they avoid factual "known-answer" questions. Such questions and the initiate-respond-evaluate classroom discourse that they foster discourage deep engagement and discussion (Hull et al. 1991). Rather, known-answer questions are avoided in the public space of the courses and are reserved for the formative and summative assessments in Steps 10 and 11. In many of our courses, most engagement routines follow a remarkably simple strategy. This strategy has each student summarize carefully curated sets of course content in order of their relevance to their own framing context. Students are typically asked to (a) summarize each element with a few sentences or a paragraph and consider its relevance to the framing context, (b) reorder the summaries in decreasing order of relevance, and (c) provide justification for the ranking (typically explaining why the first is most relevant and the last is least relevant). In the Assessment in Schools course, the first graded assignment has students use textbook guidelines while creating classroom assessments for their curricular aim. They then summarize and rank those guidelines in order of relevance. In some courses, engagement routines have been organized around carefully curated sets of open educational resources (OERs). In the biology class, students are asked to engage with and rank OERs (usually videos) for personal relevance before completing multimedia textbook assignments. In the K12 cybersecurity course, many of the assignments have students review OER videos and articles to produce ranked summaries of key aspects of cybersecurity (e.g., most significant threat actors, most important piece of security hardware, etc.).

The meaning of "relevance" in the ranking can be left somewhat open in order to help students take ownership over the ranking process and to maximize PDE. For example, the Assessment in Schools routine described above specifically instructs learners to rank the item development guidelines in order of the consequences for their own practice. This means, for example, that the more obvious guidelines for creating selected response items (e.g., *don't allow length of alternatives to supply unintended clues*) are often ranked as less relevant than less-obvious guidelines (e.g., *never use "all of the above" alternatives but do use "none of the above" alternatives to increase item difficulty*). Drawing on Gresalfi et al. (2009), this focus on actual consequences for individual practice provides a welcoming context for PDE. However, instructors should intervene appropriately if students fail to justify their rankings or provide a general (i.e., non-personalized) justification.

We are currently exploring a modification of this routine for learners whose writing skills are still developing and/or who are not learning in their first language. Instead of drafting summaries, learners cut summaries from within the body of the assignment and paste them in their draft wikifolio. They then rearrange the summaries and only need to write their justification. We included a promising variation on this technique in the Assessment BOOC. In most of the BOOC assignments, learners dragged text boxes to indicate relevance and only needed to write their rationale in an adjoining text window. We are currently unsure of the impact of this modification on engagement and learning. We are planning to experiment soon and encourage others to do so as well.

Step 4: define secondary engagement routines

Secondary routines are different than the primary routines because they build on the artifacts and insights generated in the primary routines. These routines may or may not employ the ranking routine described above and are typically introduced further into the course or program of instruction. The secondary routines are crucial for developing deeper expertise because the personalized artifacts and insights that were generated in the primary routines should be relatively concrete *after* those assignments are complete. This means that those artifacts and insights can subsequently scaffold deeper expert engagement with more abstract and advanced course topics.

For example, students in Assessment in Schools make sense of the relative complex topic of *validity* by indicating which of four types of validity evidence is most appropriate for their worked examples, which were generated in the first part of the course. They are then asked to summarize the types of validity evidence that are most relevant for their role in education. This generates predictable patterns among different types of students (e.g., teachers vs. administrators vs. doctoral students), which can then be shared back out to other students (via announcements) to further expansively frame these potentially abstract nuances.

In our experience, secondary routines often require reordering of existing instruction or textbook chapters. This is because other approaches often introduce core principles early on in instruction in the abstract, and then subsequently give leaners practice applying those principles. Put differently, PLA suggests that more abstract principles should be introduced after more practical "hands on" applied routines.

Step 5: define collaborative engagement routines (optional)

We suggest including collaborative "team-based" engagement routines judiciously, if at all. If the student and instructor social engagement routines and expectations (Steps 7 and 8) are designed and implemented effectively, there should be extensive *social* engagement that is both productive and disciplinary. We believe that unless targeted competencies are explicitly collaborative, most designers should avoid creating collaborative routines for the sake of collaboration. Collaborative activities require coordination, which many online students may find difficult to manage. Additionally, collaborative routines can require non-disciplinary learning (e.g., how students are expected to collaborate on the joint task) *before* actual disciplinary engagement occurs. Group-based activities can also result in friction that undermines engagement and requires instructor intervention. Of course, for disciplinary knowledge and practices that are inherently collaborative, we assume that collaborative engagement routines will be necessary.

Step 6: define arbitrary engagement routines (as needed)

We have found that some courses in some disciplines will include content that learners will find difficult to problematize from their own perspective. For example, in the cybersecurity course, some of the content (e.g., "hashing") was difficult to frame expansively. In these cases, both the K12 network analyst and network engineer interviewed for the assignment podcast struggled to frame those topics using their networks. Nonetheless, they also agreed that students still needed to learn about the topic. However, the podcast also reminded students that engaging with a topic enough to realize it can't be framed expansively is still productive. In such cases, expert and even arbitrary (i.e., unbounded) engagement routines may be needed.

Many of our insights around this step come from the ongoing biology course. Rather than an overall framing activity (Step 1), each assignment first instructs students to view an introductory OER video and then complete an introductory engagement routine called *Contextualization* that focuses on the topic of the assignment:

> At the top of your wiki, say a few things about your previous *experiences*, current *interests*, and future *goals* as they relate to learning these main ideas and objectives. For example:
> *Did you ever learn about ________ before?*
> *How does ________ relate to other things you learned or will learn in this class?*
> *How might you use this knowledge of ________ in the future?*
> It is ok to say you don't have any idea, but you should probably be able to come up with something in your past, present, and future to relate this to. Even if you don't, thinking hard about this will help you make sense of your classmates' relevant experiences. Look at the posts of your classmates if you need examples and inspiration.

Initial analyses have confirmed that most students are able to respond meaningfully to these introductory routines in each assignment; in most (but not all) cases, students then use that assignment-specific frame to shape their responses to subsequent primary and secondary engagement routines.

Step 7: define student social engagement expectations and routines

In our online courses, social engagement routines help students hold each other accountable to disciplinary norms. They also position students as the audience of their peer authors. Rather than having students interact in discussion forums, all peer interactions occur via comments and threads posted directly on students' wikifolios. While it is certainly possible to support PDE in online discussion forums, they are often inefficient for students and exhausting for instructors. Because discussion forums are necessarily removed from student work, they can tend towards abstractions, which struggling learners can find overwhelming—particularly when participation is required and graded.

Most of our assignments instruct students to post a question to their peers in the form of a comment and then engage with their peers by responding to their questions. In order to minimize unproductive obligatory posts, peer interaction is not graded and is usually not technically required. We expect some readers to find such expectations counter-intuitive at first. We find inspiration in Jenkins' (2009) definition of "participatory culture" whereby *individuals are not required to participate but know that when they do their contributions will be valued.*

These social engagement routines illustrate why it is important to avoid "known-answer" questions in the public space of a course. For example, students will sometimes appear to have ranked an element of an assignment as "least relevant" because they do not fully understand that element. This creates a safe and welcoming context for peers and/or instructors to point out unrecognized relevance. This sometimes leads authors to revise their rankings. When this occurs, the instructor points to it (via a hyperlinked announcement) as a particularly productive form of disciplinary engagement and encourage all students to do the same with their peers. This particularly productive form of engagement is unlikely in assignments organized around known-answer questions.

Motivational strategies

PLA assumes that most students are enthusiastic about discussing their own work. This is particularly so when students have effectively been positioned as the local expert regarding the artifact being discussed. Over the years, we have experimented with a range of ways of encouraging and rewarding the most productive forms of peer engagement. For example, in some courses, students are instructed (but not required) to promote one peer post or comment per assignment as being "exemplary." They do so by posting a comment that starts with a distinctive string of punctuation marks (e.g., "!!!") and explaining what specifically they found exemplary. This feature was automated and expanded to include peer *endorsement* (as "complete") and peer *promotion* (as "exemplary") in the Assessment BOOC (as described in Hickey and Uttamchandani 2017).

Readers should note that our use of the controversial term "reward" in our second PLA design principle was quite deliberate. We are acutely aware of the enduring debates over consequences of extrinsic rewards on metacognition and free choice engagement (e.g., Cameron and Pierce 1996 vs. Deci et al. 2001). As introduced above, we believe that situative models of motivation and the use of inherently meaningful rewards can sidestep these concerns and transcend this corrosive debate. This argument is elaborated elsewhere (Hickey 2003; Hickey and Schenke 2019) and supported empirically in Filsecker and Hickey (2014). In short, we believe that our approach does so because this debate is rooted in the fundamental epistemological differences between information processing and constructivist approaches. In theory, we treat both behavioral responses to reward and praise from others *and* the pleasure experienced with solving interesting problems as special cases of socially situated activity. Pragmatically, we suggest that designers and instructors evaluate the impact of social engagement strategies *primarily* in terms of their impact on PDE and only *secondarily* in terms of their impact on (observed) learner behavior or (inferred) intrinsically motivated learning. As described next, this means focusing instructor recognition and encouragement on PDE (rather than the learning presumed to follow from that engagement); this motivational practice is further reinforced with the reflections and assessments (Steps 9, 10, and 11) described below.

Step 8: define instructor engagement expectations and routines

Once the courses are designed, the engagement of the instructor/facilitator is the most important factor in supporting PDE. A central goal of PLA is maximizing the impact of every public instructor comment. Providing feedback in the form of local comments that all students can read bypasses the massive workload generated when instructors try to privately critique and grade every students' work *and* participate in every discussion forum thread. We believe that these two tasks are a major source of the online instructor "burnout" described in Hogan and McKnight (2007). Rather, instructors are expected to model, encourage, and reward the most productive forms of engagement, but not necessarily participate in every peer exchange and respond to every question. Additionally, we point out that some forms of instructor engagement can dramatically undermine PDE. For example, instructors need to avoid undermining learners' positions as the local expert in their framing context; likewise, instructors should not use their expertise to "close" questions that are productively "open" for learners. As with student engagement routines, we encourage instructors to evaluate the impact of their own engagement strategies in terms of their impact on learner PDE.

This instructor commenting strategy illustrates how the "public and persistent" discourse that is unique to asynchronous online courses and hybrid assignments can support levels and forms of engagement that are difficult to accomplish in face-to-face or synchronous settings. While Steps 9, 10, and 11 free up instructor time for public engagement, it is still important for instructors to make the most efficient use of their time. While most courses and many classes will take on patterns and structures of their own, careful consideration when designing courses and during early stage implementations should allow informal expectations and routines to be established that are efficient and productive for instructors *and* students.

We expect that one of our most counter-intuitive recommendation for instructor engagement concerns the introduction of very advanced concepts. Such concepts and their nuanced application in context are ultimately central to true expertise in any domain. But they are also the very concepts that are likely to overwhelm and/or frustrate learners with less experience and/or ambition. We sometimes address such concepts in optional assignment elements, but we often find that even the most ambitious students don't complete optional elements. Rather, we regularly introduce these more advanced concepts in public instructor comments that are framed by one or more examples of student work. In most courses, we find that the more experienced and ambitious students will post well before assignment deadlines. We suggest that designers create secondary engagement routines that are likely to surface these issues. We then suggest that instructors (a) provide relatively extensive feedback to the more ambitious early posts, (b) include more advanced concepts in that feedback, and (c) post a hyperlinked announcement encouraging others to examine the early posts and instructor feedback *after* they have begun working on the assignment. This is certainly another aspect of our framework that begs for systematic investigation.

Step 9: create public informal assessments of engagement

This step reflects our belief that direct assessment of student artifacts for evidence of disciplinary knowledge is imprecise and laborious. In our experience, many online instructors find doing so to be excruciating. Doing so requires significant knowledge of the content, how that content is learned, and how that content learning is or is not supported in the particular course. This knowledge is often scarce among potential online instructors. Such grading consumes a relatively large amount of private instructor-student interaction that is not particularly productive, while still resulting in conclusions about knowing that are not particularly valid. Furthermore, when instructors deduct points from artifacts for lack of knowledge, students will often challenge that conclusion, claim the assignment was confusing, and/or demand individualized feedback on interim drafts. We believe this is another major source of online instructor burnout.

Instead, prompts are used to guide students to add public reflections on their engagement at the bottom of their wikifolio, *after* they have completed the formative self-assessment (Step 10) and have interacted with their peers and the instructor. Here are the five prompts currently used in the Assessment in Schools course:

- *Contextual engagement*: How useful was your [framing context] for applying the concepts in the assignment? Did any of your peers have a [framing context] that seemed more suited to this assignment than yours?

- *Collaborative engagement*: What did you learn from your peers and what did your peers learn from you? Which exchanges did you find particularly productive?
- *Consequential engagement*: What will you do differently in the future because of this assignment?
- *Conceptual engagement*: How well were you prepared for the formative assessments? Did you struggle with any of the concepts?
- *Cultural engagement*: How did your race, ethnicity, gender, orientation, SES, and (dis) ability impact your engagement?

To reiterate, these reflections (a) are informal and public, (b) build on Gresalfi et al.'s (2009) ideas about consequential engagement, (c) are intended to help formalize the intercontextualities generated in the assignment, (d) shape prior engagement proleptically, and (e) serve as summative assessments of prior engagement. In most courses, these reflections are used for awarding points for completing each wikifolio and comprise a large proportion of the grade (50–70%). As long as students complete all elements of the assignment and post coherent reflections by the deadline, students are awarded full points for the assignment and a few private comments in the gradebook. In our experience, more extensive private feedback is only called for when instructors deduct points for incomplete assignments (e.g., unjustified rankings) or for being late.

While the first three reflection prompts have been used for over a decade, last two prompts were introduced recently. The conceptual reflection is intended to help motivate students to engage seriously with the formative self-assessments and help maximize formative impact on achievement. The cultural reflection was added to encourage engagement with sociopolitical controversies. The cultural reflection is consistent with some of the goals that Agarwal and Sengupta-Irving (2019) advanced in their Connective and Productive Disciplinary Engagement (CPDE) framework. The CPDE framework aims to surface issues of history, power, and culture that may otherwise be overlooked. Initial efforts confirm that this relatively modest feature does indeed surface such issues and provide a comfortable space where instructors can *reposition* the engagement of minoritized students. In one recent study (Hickey and Quick 2020), the addition of the cultural reflection combined with deliberate instructor repositioning of minoritized students led to a dramatic increase in the use of sociopolitical controversies to problematize content (from 15 to 44%). The cultural reflection and repositioning also helped students from linguistic and racial majorities recognize their inherent power and privilege that they might otherwise not recognize or take for granted. This is another aspect of the PLA framework that begs for more systematic investigation.

Step 10: create private semi-formal assessments of understanding

This step concerns assessments of conceptual understanding of targeted concepts and/or fluency with targeted skills. In most of our courses, this is accomplished with 5–7 open-ended self-assessment items that are included at the end of each assignment (but before the reflections). These are completed privately and require no input or effort on the part of the instructor (other than ensuring that the several strategies intended to motivate students to complete them are working).

These assessments present "known answer" constructed-response or performance assessment items. As such, they are one level removed from the reflections, and doubly removed from the engagement routines. These assessments are "proximal" to the curriculum and they are intended to summatively assess understanding of targeted concepts while formatively assessing achievement as measured by the distal tests (Step 11). Because these items are removed from the individualized framing context, concepts may need to be framed using more generic expert-framed contexts (particularly if using performance assessment formats). In some cases, we find useful items in the item banks provided by textbook publishers. In other cases, we have found useful items in textbooks themselves. For obvious reasons, we suggest avoiding items in assigned textbooks when the textbook includes direct answers.

We acknowledge the widely-held assumption that formative feedback *from educators* is necessary to advance students' conceptual understanding. PLA assumes that self-assessment can have substantial impact when items and answer explanations are well-constructed, and students are prepared for those assessments and motivated to engage with them as instructed. To accomplish this, these assessments are designed to be answerable by all students who have engaged productively, but still require some transfer from the assignment. Students are reminded (a) that the assessments will help prepare them for the graded tests, (b) to first attempt to answer each item from memory, (c) to search for additional information, if needed, in their wikifolio or other resources to draft an acceptable response, before (d) comparing their answer with the relatively detailed expert answer provided by the testing interface. Consistent with constructivist theory, the self-assessment should prompt metacognitive processes that focus attention and memory in ways that make students receptive to more advanced and nuanced insights that go beyond the "correct" answer.

Step 11: create discreet summative achievement tests

These are tests (or "quizzes" or "exams") that capture valid evidence of student achievement of the more general standards targeted by the course or the instruction. In most of our courses, these consist of multiple-choice quizzes for clusters of assignments (i.e., "module quizzes") that are automatically scored in the learning management system. These are designed to protect the security of the tests and validity of the scores as evidence of potential transfer; these test are further intended to avoid obtrusive and costly online proctors and avoid requiring online students to be physically present on campus or a remote testing center. Most of our tests are time-limited (typically around two minutes per item) and consist of challenging items whose answers can't be readily located by students who have not engaged with the assignments.

These tests are "discreet" in that they are never allowed to directly shape instruction and typically add up to a fraction of the overall grade (typically 30%). Significantly, the curriculum and formative assessments should NOT deliberately expose students to the several specific associations that make up each test item. This is because of the very shallow "recognition-level" memory threshold needed for such associations to transfer from the curriculum to the test. In our experience, good items can sometimes be obtained from the item banks provided by textbook publishers (which may have been created by professional item writers). Regardless, all test items should be scrutinized for three common shortcomings. First, they should be scrutinized using well-established item development guidelines and not provide unintentional clues. Second, items should be scrutinized for difficulty. Most items should be challenging "best-answer" items where multiple responses might appear correct to underprepared students. If "correct answer" items are included, they should concern relatively advanced concepts and be structured so that all four or five responses (and not the item stem) would need to be searched, as described next.

Finally, and most importantly, each test item should be scrutinized for searchability. Specifically, designers should search for the answers to the items in the textbook or other course resources, and search for the answers in Google Search. If the textbook or course resources readily reveal the correct response without requiring some engagement (e.g., the answer is provided in a glossary), the item should be revised or replaced. In our experience, many students (but fewer instructors) know that most LMSs allow test takers to "right click" test item stems to search Google for answers—without leaving the LMS. Because so many other students are searching Google for similar questions, the results will display links to the similar questions. Even with well-constructed items, prior students may have posted "flash cards" to sites like Quizlet.com or OneClass.com, or posted "study guides" at sites like Reddit. In some cases, students will post exams and answers. This is particularly likely with popular textbooks and courses that are taken by thousands of students.

Once courses are underway, tests and items should be scrutinized using the item analysis tools provided by all modern LMSs and Google Forms. This will identify items that are not behaving consistently relative to overall scores (i.e., *d* or discrimination), are too easy or too difficult, or appear to have been compromised. In graduate courses, we aim to have no more than one student earning a perfect score and have scores normally distributed around an average around 80%. In order to preserve test security, items are presented one at a time (to make it difficult for students to print them out and share them) and students are only shown their overall score. In our experience, some students argue that it is "unfair" or "unproductive" to not show correct answers and/or insist that some of the items had multiple correct answers. We respond by telling students that the potential for compromising test security outweighs the miniscule formative value of providing answers and explaining that the students who get the most difficult items correct usually get all of the other items correct.

Some students (e.g., in graduate courses) may object to purely summative achievement tests. We contend that well-constructed and secured achievement tests can *efficiently* provide reliable scores that allow valid comparisons of relative knowledge of course content. As such, they are appropriate evidence for awarding grades *and* estimating the extent to which learning will transfer to other educational, professional, achievement, and personal contexts. We further contend that summative tests help motivate students to engage meaningfully in the various engagement routines and formative assessments. We also believe that automated selected-response formats eliminate one of the most burdensome tasks for many instructors. In this way, these tests free up time for instructors *and* students for more productive forms of engagement.

Step 12: create model wikifolios, podcasts and/or videos (optional)

We suggest that designers consider creating a model wikifolio for students to reference. In some settings, creating such an example may be an ideal way for an individual to prepare to facilitate a course that was designed by someone else. Because students are likely to reference and discuss such an example, this strategy can prepare inexperienced facilitators (e.g., graduate students) to model and scaffold PDE when they are getting started.

In larger courses, it may be worthwhile to create podcasts or videos for some or all assignments. While these resources should *reference* course content, they should not be created to *deliver* course content. While they may introduce course content, their primary function should be modeling the forms of engagement with other course resources expected of students. In our courses, all videos and podcasts are designed and produced to be conversational. The instructor or experts articulate their own framing contexts and then engage with course concepts in the same way that is expected of the students. For example, videos in the Assessment in Schools course featured the instructor explaining how he applied the topics in each assignment in his own courses (starting with the Assessment in Schools course itself). For the podcasts in the K12 network analyst courses, designers interviewed an early-career K12 network analyst and a seasoned K12 network designer. The interviewers asked them to describe and contrast how assignment topics were taken up in their respective positions. We found that (a) interview/conversational recordings (and particularly podcasts) are vastly easier to create than more formal, structured content-delivery recordings, (b) such recordings can help students define and refine their frames while modeling highly productive forms of disciplinary engagement, and (c) creating such recordings can help define/refine engagement routines. Nonetheless, recording is still laborious; we suggest course designers first explore whether a model wikifolio is sufficient.

Step 13: create microcredentials (optional)

The public nature of student engagement in PLA courses is ideally suited for recognition with microcredentials (i.e., web-enabled digital badges; Gibson et al. 2015). In most learning management systems and Google platforms, it is now possible to (a) automatically issue badges that include hyperlinks to completed work, (b) make badges contingent on completing assignments and/or earning particular quiz scores, and (c) create badge "pathways" whereby a "metabadge" is awarded for completing the entire course, including the module badges earned along the way inside of the course badge.

As elaborated in Hickey et al. (in press), the wikifolios and threaded discussions associated with the PLA framework are ideal for recognizing so called "21st Century" competencies like collaboration, creativity, and critical thinking. By including links to this evidence, instructors can avoid the messy and laborious process of formally assessing these highly contextual competencies. Rather, observers for whom this evidence is important and meaningful can make those judgements for themselves. Indeed, an extended study of the 30 badge systems funded in a 2012 competition found that the badge systems that issued such "participation" badges were most likely to result in a thriving educational ecosystem (Hickey and Chartrand 2020). In contrast, few of the other projects that attempted to issue constructivist "completion" badges or associationist "competency" badges resulted in thriving ecosystems. Reinforcing our arguments above, most of the other badge systems were suspended because of unsustainable expectations for individualized formative and summative assessment of student work; some of the proposed systems were never even implemented because of unattainable assessment expectations.

Readers should note that if student work is to be accessible outside of the LMS, wikifolios likely need to be completed as Google Docs (i.e., "gPortfolios"). Fortunately, students can adjust the sharing settings in Google Docs to suit their desired privacy (so long as they understand the evidential tradeoffs). Additionally, the notification settings in Google Docs make it possible for students to receive hyperlinked emails anytime someone posts a comment to their work; this in turn facilitates peer interaction even among students who have completed self-paced courses.

Step 14: design homepage, submission, and grading systems

Of course, other features will be needed before students can enroll or participate in a course or a module of instruction. Most of these features will be unchanged when using PLA. However, most designers will want to add a wikifolio homepage where students can paste links to their wikifolios once they have drafted them.[1] Additionally, designers should carefully consider their instructions for "submitting" assignments. In some courses, students might be instructed to submit the URL for their wikifolio; we suggest also asking students to provide any private instructor feedback on any elements of the assignment that they found confusing or unproductive. Additionally, in cohort-based courses, we typically penalize students for posting late wikifolios. We have found that a small-but-strict 1% per day penalty is sufficient to ensure a critical mass of engagement around deadlines.

Next steps and future research

As design researchers, we hope that others will adapt this framework to new content and settings, and share out the new insights that emerge. We are particularly hopeful regarding new efforts in STEM contexts. Perhaps the most important question raised by this new stepwise presentation is whether educators and designers who are not grounded in sociocultural theory are indeed able to successfully design and/or teach new courses using this approach. We welcome such investigations and encourage doing so using newer design-based *implementation* research methods (DBIR; Penuel et al. 2011) within research practice partnerships (Coburn and Penuel 2016).

With this new presentation and a wide range of courses and contexts, we believe that the PLA framework is now a relatively mature instructional design framework. We believe it is now ready to be (a) *scaled out* to other online educators and course designers and (b) *scaled up* and used to offer more interactive MOOCs. We believe it is now time to create new versions of existing courses or MOOCs using PLA and experimentally compare historical retention, engagement, satisfaction, and learning outcomes. By using typical anonymous end-of-course evaluations and by including the outcome measures from the existing course, it should be possible to carry out relatively convincing objective comparisons in many settings. We further believe that such studies would be ideal for graduate student theses or dissertations. This is because such designs would afford both empirical and interpretive analysis while also contributing useful new insights to the PLA design principles.

We also believe that it will be interesting and worthwhile to revisit the challenges of online STEM courses using this new format. To reiterate, we assume that this new framework will help designers and facilitators who are not grounded in sociocultural learning theories to "learn as they go." But this remains to be seen. We also believe that this framework is ready for more rigorous analysis of student engagement. Research is now underway using micro-analysis of online data and conversation analysis (MOOD and CA; Giles et al. 2015) in several courses. These methods can provide objective evidence of the extent to which students are using language to engage in PDE and hold themselves and each other

[1] It is worth noting that the popular *Canvas* LMS currently does not allow threaded comments on student-generated pages. As such, students are instructed to generate a new discussion forum for each assignment and to complete their wikifolio in the header of the discussion. These discussions can be accessed from the discussion home page, along with the number of read and unread comments. However, doing so does not distinguish between incomplete and complete drafts.

accountable. Just as Lester and Paulus (2011) showed that STEM student bloggers used *hedges* to resist accountability (i.e., "I don't know about ________, but …"), we expect that these methods will document the extent to which students in these courses embrace accountability. One of these ongoing efforts is exploring whether social learning analytics (e.g., Shum and Ferguson 2012) might automate such analyses.

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Compliance with ethical standards

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