

Gail Matthews-DeNatale, NORTHEASTERN UNIVERSITY, g.matthews-denatale@northeastern.edu
Laurie Poklop, NORTHEASTERN UNIVERSITY, l.poklop@northeastern.edu
Rachel Plews, SUFFOLK UNIVERSITY, rachel.plews@suffolk.edu
Mary English, NORTHEASTERN UNIVERSITY, m.english@northeastern.edu



Global Challenges: Engaging Undergraduates in Project-Based Learning Online

ABSTRACT

In summer 2020, Northeastern University developed a fully online curricular pathway for incoming fall first-year undergraduate students who could not learn in residence. This pathway included 18 Global Challenge (GC) courses, each designed around project-based learning (PBL), grounded in a complex problem defined by Northeastern University research faculty, and based on the classes' individual research agendas (e.g., social justice, health, the environment). The GC courses were designed to help students develop key intrapersonal and interpersonal skills as well as academic proficiencies. The GC development team conducted a systematic study of the courses during the first three semesters of their development and implementation. The investigation's guiding question was, "To what extent, and in what ways, can learning experience design, online structure, and facilitation support PBL learning, teamwork, and a sense of connection among students in asynchronous courses?" Data sources included student surveys, instructor reflections, and course observations. Findings highlighted the importance of a learning experience design infrastructure to support PBL challenge development; that design supports for challenge development are necessary, but not sufficient, and an online course architecture that reinforces PBL also needs to be developed; that student attention to course resources needs to be scaffolded within the course and optimized for the online modality; and that a system for instructor mentoring in online PBL pedagogy is important to course success.

KEYWORDS

project-based learning, problem-based learning, online learning

INTRODUCTION

Northeastern University, originally founded in Boston, Massachusetts within the United States, is a globally networked university with 14 campuses in three countries. Northeastern is also an R1 university, meaning it has a research focus, and it is best known for its commitment to interdisciplinary experiential learning. In the summer of 2020, Northeastern invested considerable resources to create an intentionally designed, asynchronous online pathway for incoming first-year undergraduates who were from locations around the world. Priority was placed on developing courses that reflected Northeastern's commitment to use-inspired research that engages faculty in the pursuit of novel solutions to seemingly intractable societal challenges that have national and international relevance.

The Global Challenges suite of 18 courses reflected these institutional priorities. Each Global Challenge course was structured around one complex interdisciplinary problem derived from faculty

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research, and they were designed to be a distinctively Northeastern University learning experience. Challenges concerned pressing issues such as antibiotic resistance, systemic racism, sustainable fisheries, and immigration justice.

Intended for first-semester undergraduates and then also made available to pre-matriculated students, GC courses were designed to help learners develop key intrapersonal capabilities (e.g., self-directed learning) and interpersonal skills (e.g., virtual teams). In addition, the Challenges projects were designed to involve students in one or more core academic processes identified by the university as priorities for undergraduate learning: engaging in the natural and designed world, understanding societies and institutions, engaging differences and diversity, and employing ethical reasoning (Northeastern University n.d.). Course goals are summarized in Figure 1.

Figure 1. Global Challenge course goals



Established models for project-based learning (PBL) with an “ill-structured” problem at its core informed the course design (Buck Institute 2003; Kingston 2018). Ill-structured problems are complex, significant ones that require multiple disciplinary dimensions of understanding to address and have no straightforward path to a solution. With the support and feedback of the course facilitator, students in PBL work in teams to tackle the problem and propose an evidence-based response.

Randy Bass maintains that PBL has the capacity to cultivate students who see themselves as an “agent of positive change in the world” who have the capacity for “critical thinking, creative problem-solving, empathetic engagement, and ethical judgment” (2019, vii). He also asserts the need to “seed project-based learning in the very foundation of a college education” because “these capacities, so critical to the future of our society, should be the place where this kind of education should begin, not end” (viii). Northeastern’s decision to engage first-year students in sustained PBL work through a Global Challenge project aligns with Bass’ vision for involving undergraduate learners, from the outset of their education, in complex problem-solving that requires deep, sustained investigation of challenges. This includes drawing on knowledge from multiple disciplines to propose responses that address the concerns of multiple stakeholders.

PROJECT-BASED LEARNING ONLINE: THE LITERATURE

To inform their research, the development team reviewed literature in the areas of project-based learning, online learning, and online project-based learning. More specifically, this includes

how learning design, the structure of the online learning environment, and course facilitation can foster PBL learning, teamwork, and connection. This review of the literature begins with an exploration of the defining characteristics of PBL and how it supports the formation of undergraduates as critical thinkers and problem-solvers. Following that is a discussion of the literature associated with asynchronous online learning, especially studies relevant to online PBL and ones that explore potential synergies in constructivist approaches to online learning and PBL. The literature review concludes with research focused on online PBL in higher education, providing a backdrop for how the Global Challenge project's approach to online PBL design and facilitation impacted student learning.

Project-based learning

There are several approaches to project-based learning (Kokotsaki, Menzies, and Wiggins 2016). The Buck model leveraged for Global Challenges defines project-based learning (PBL) as “a systematic teaching method that engages students in learning knowledge and skills acquired through an extended inquiry process structured around complex, authentic questions and carefully designed projects and tasks” (Buck Institute 2003, 4). Jennings (2006) expanded the definition of PBL to include students working in teams as they conduct inquiry around a real-world problem and propose viable solutions. PBL embodies a constructivist approach to teaching where students learn inductively through a form of cognitive apprenticeship (Brown, Collins, and Deguid 1989; Steinkuehler et al. 2002). Often, this includes modeling, scaffolding, and addressing feedback from the instructor and peers (Savery and Duffy 2001). Intentionally designed student projects foster integrative learning, one of the high-impact practices known to contribute to enhanced student learning, engagement, and retention (Bass 2019; Kuh and Schneider 2008).

The intentional design of the PBL learning environment involves developmentally appropriate scaffolds that foster self-directed learning and critical thinking through self-monitoring and self-reflection (Rillero and Camposeco 2018). One project, grounded in a real-world problem, is the central element of the course. It is divided into three distinct phases. The first phase (launch) introduces an open-ended, actionable driving question that frames and scopes the problem of focus. Students then generate a list of “need-to-knows” (NtK), or questions they need to address to answer the driving question. In the next phase (inquiry and solution development), students iteratively conduct inquiries to answer their NtK questions and develop a solution to the problem. Resources such as readings, mini-lectures, and guest speaker interviews are made available to help students answer their questions, along with any scaffolding activities deemed necessary or helpful to the problem-solving process. In the final phase (showcase and reflection), students share their results and reflect on the process. The sustained inquiry in relation to an unmet need and challenge and the full course length of the project make it a project-based course, rather than a course with a project. This full course length provides the time for a transdisciplinary project, allowing students to engage more deeply in the complexities of these real-world problems (Boudreau and Rosbach 2019).

PBL has been demonstrated to be effective in igniting learner motivation and engagement (Mebert et al. 2020; Parsons and Taylor 2011), facilitating knowledge acquisition and retention, promoting transfer of learning to other contexts, increasing career readiness and self-efficacy, and fostering development of personal and professional skills such as teamwork, communication, organization, and planning (Dunlap 2005; Wurdinger 2016). A comparison of PBL with traditional lecture and discussion indicated increased change in thinking, engagement, and perception of content relevancy (Wynn, Mosholder, and Larsen 2014).

However, according to English and Kitsantas (2013), “In order to be successful in problem- or project-based learning (PBL), students must take responsibility for the learning process by setting goals, monitoring, reflecting, and sustaining their motivation from the beginning of the project until the end” (128). Therefore, using a project-based approach often necessitates changes in classroom management and teaching strategies. For these reasons, teachers sometimes report difficulty or feel underprepared when making the transition to this more student-centered approach (Blumenfeld et al. 1991; Bradley-Levine et al. 2017; Ertmer and Simons 2006; Marx et al. 1997). Given the amount of preparation that is required and the challenges associated with effectively facilitating projects, it is essential to consider the best way to prepare and support teachers (English and Kitsantas 2013; Guskey 1988).

Design and facilitation of asynchronous inquiry-based online learning

PBL learning experience design has much in common with constructivist approaches to online learning (Kelly 2008); both focus on the support and facilitation of students’ construction of knowledge and processes that support meaning-making and understanding (Conrad 2005; Lee 2009), rather than knowledge transmission. Early definitions of online learning (Smaldino, Lowther, and Mims 2018) emphasized the technologies and multimedia used to deliver instruction. More recent definitions consider the complexities and pedagogical affordances of this modality (Sing and Thurman 2019).

Constructivism is not inherent in online learning as a modality; as with face-to-face instruction, online courses are often highly structured with a deductive approach to teaching. However, there has been growing recognition of the importance of active learner engagement in online learning contexts. According to Moore, Dickson-Deane, and Gaylen (2011), “eLearning is not only procedural but also shows some transformation of an individual’s experience into the individual’s knowledge through the knowledge construction process” (130).

Strategies to increase interactivity and active learning and foster communities of learning are among the most researched areas of online learning over the past few decades (Berge and Mrozowski 2001; Zawacki-Richter, Backer, and Vogt 2009). In a systematic review of the literature, Martin, Sun, and Westine (2020) examined the research around engagement in online learning, noting themes in the areas of presence, interactions, building community, participation, collaboration, involvement, and communication. More recent publications have grounded discussion about online course design and facilitation in the learning sciences (Darby and Lang 2019; Miller 2016).

The Community of Inquiry (CoI) framework provides guidance for designing and facilitating deep learning through constructive engagement online (Garrison, Anderson, and Archer 1999). The framework articulates three forms of presence that are essential to learning effectiveness: cognitive presence, teaching presence, and social presence. Linkages between past understanding and newly acquired knowledge, social interactions, coordinated efforts between peers, and direct application of knowledge to the learner’s daily life are foundational to successful online learning that builds learner capacity for self-regulation and self-reflection (Cercone 2008; Garrison 2007; Ke 2010; Kilis and Yildirim 2018; Moore and Miller 2021). These learning experience design features are also foundational to successful PBL courses (English and Kitsantas 2013; Rillero and Camposeco 2018).

According to Garrison (2017, 2022), cognitive presence is operationalized through the four phases of practical inquiry: a triggering event, exploration, integration, and resolution. This aspect of the CoI framework aligns with the phases of PBL, indicating a potential synergy between PBL and online learning theory. CoI’s “triggering event” corresponds to the initial step of PBL, when the

instructor poses a problem that the students will work on together. The exploration and integration phases correspond to PBL's iterative problem-solving phase, during which students gather information about the problem (Moore and Miller 2021) and why change is needed (e.g., its history, impacts, differing perspectives, and possible causes) and then synthesize and integrate different ideas, further considering what has already been done about the problem in the past. The resolution phase corresponds to the final phase of PBL, in which students propose a real-world solution to the problem, providing an argument as to why this solution is the most appropriate.

Online project-based learning

There is a paucity of research about student learning in online PBL environments. In the early 2000s, many studies related to inquiry-based learning online emphasized technology over pedagogy: for example, the types of multimedia used to develop the online PBL environment and the tools utilized to foster collaborative interactions (Jennings 2006; Omale et al. 2009; Savin-Baden and Gibbon 2006). However, there were also studies that concentrated on inquiry-driven learning design (Harlen and Doubler 2004) and the role of the instructor as a facilitator that stimulates discussion and increased interaction in the online environment.

Several recent studies compare online PBL with other approaches in specific disciplines. For example, Aslan (2021) explored the impact of an online PBL approach on multiple student outcomes in a first aid course, as compared to a more teacher-centered approach (e.g., lecture). Except for communication (which showed no difference), the PBL students in the study demonstrated higher gains on all measures, which included learning achievement, problem-solving skills, communication skills, and level of interactivity. A similar study conducted with dental students found that students' self-perception, motivation, organization, clinical skills, and knowledge in online PBL were more effective for certain aspects of clinical dental education compared to traditional teaching methods (Morgado, Mendes, and Proenca 2021).

Other studies have examined the affordances of online PBL and challenges faced by learners and facilitators (Erikson et al. 2021). Themes include the flexibility offered by the online PBL format, how students and facilitators felt compared to face-to-face PBL, and perceived challenges of learning activities, including the development of rapport, having good conversations, and getting to a place of deep learning.

Drawing on our knowledge of the research findings associated with PBL and online learning, we anticipated that effective design of engaging challenges would be key to student motivation and substantive learning. In addition, we realized that we needed to develop an online course structure and system of support for facilitation that would reinforce the inductive learning process essential to PBL.

RESEARCH TEAM, QUESTION, AND METHODOLOGY

Research team

This SoTL study was carried out by a team of four learning experience designers with significant expertise in PBL, online learning, and educator development. This team, hereafter referred to as the "development team," also had responsibility for course design, the development and facilitation of a system for instructor orientation, and ongoing oversight of course quality across semesters. Individual members of the Global Challenges development team tended to have expertise in either PBL or online learning. Experts often make assumptions or overlook key aspects of their knowledge that may not be readily apparent to those with less experience. One of the challenges

essential to both team and project success was reconciling differing areas of individual development team member expertise.

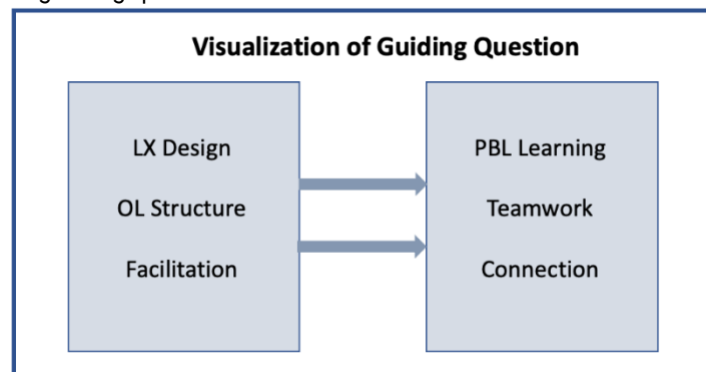
Through extensive conversation and mutual discovery, the team was able to leverage individual knowledge of the research findings associated with PBL and online learning. They anticipated that effective design of engaging challenges would be key to student motivation and substantive learning. In addition, they realized that they needed to develop an online course structure and system of support for facilitation that would reinforce the inductive learning process that is essential to PBL.

Anticipating that there would be discoveries along the way that would be worth sharing, the team decided to embed SoTL into the project from the outset. The university ethics board formally approved research related to the Global Challenge project. The development team integrated a SoTL-informed, systematic process of evidence-gathering and reflection into their work across multiple semesters. This process proved to be invaluable as the team used the findings to make informed and intentional iterative improvements to both the course structure and the systems of support for course facilitation.

Guiding question

Poole (2018) asserts that intuition, anecdotes, and observations are rich sources for SoTL questions. The guiding question was born from the goals of the program, and the team’s observations about the specific needs of first year undergraduate students who would be learning inductively and asynchronously from around the globe. The team’s knowledge of the challenges and critical success factors under these circumstances inspired the following guiding question: “To what extent, and in what ways, can learning experience design, online structure, and facilitation support PBL learning, teamwork, and a sense of connection among students in asynchronous courses?” This question is illustrated in Figure 2.

Figure 2. Visualization of guiding question



Methodology

The team revisited its guiding question at the end of the first three terms when the courses were taught. They viewed it through the lens of the following data sources: student surveys, instructor reflections (written and verbal), and course observations (including interactions and student work).

Student surveys

Student surveys were staged in Qualtrics and administered to all students across all sections at both the midpoint and the end of each semester in fall 2020, spring 2021, and summer 2021. The online survey consisted of 12 Likert scale questions with a four-point scale (not at all, a little, somewhat, and significantly), each with optional comment boxes. Sample questions included:

- To what extent have the guidance and instructions in Canvas helped you understand how to successfully complete the coursework?
- To what extent do you feel connected with other students in the course?
- What factors have played a role in your motivation?
- To what extent have activities, information, and resources been helpful in learning about the topic and completing coursework?
- Which communications have been most helpful? Which have been least helpful? Why?
- To what extent has receiving feedback from the following sources been helpful in learning about the topic and completing your coursework?
- To what extent has your experience in this project course prepared you to do each of the following in future coursework?

The survey gathered information on where students were located, and about half of the students were in countries beyond the United States. Sample international locations included China, Indonesia, Singapore, and Bolivia. Information such as race, ethnicity, first language, and self-identified disability was not gathered. While more granular information about learners could have been useful, there were concerns about survey length affecting response rate.

Even though the survey response rate was robust (ranging from 30–50% for each of the three semesters) the response rates per course were not sufficient to disaggregate and draw statistically significant conclusions, and each course section had a different challenge focus and facilitator. Thus, the team decided to not focus on quantitative results. Instead, the responses to open-ended questions provided a rich portrait of the overarching learner experience with online PBL, and a qualitative analysis of this data revealed consistent themes across respondents in all sections and all nationalities.

Instructor reflections

Instructor reflections were documented through written journals, notes taken by the development team during synchronous sessions with the instructors, and a final survey of the instructor experience. In the instructor reflections, areas of focus included exploring their developing understanding and capacity for online PBL instruction (e.g., the facilitator’s role in supporting inductive learning and community-building online).

Course observations

Course observations were conducted by a member of the development team every other week using an observation template. These were then shared as individualized “mentor feedback” with instructors. Areas of focus in course observations included instructor responsiveness, climate and tone, and clarity. These observations also helped the development team see the courses from the instructor-student vantage point, noticing details of interaction with course content and with each other that were not apparent until the online courses were underway.

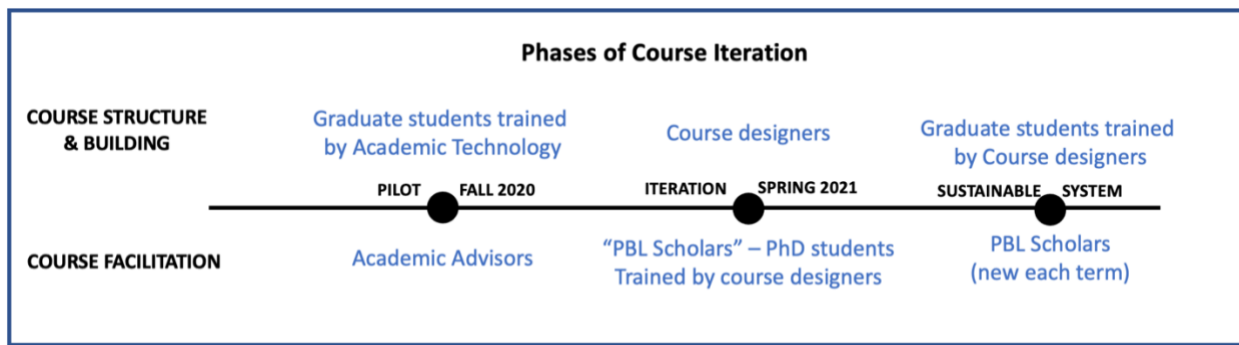
Triangulating the insights gleaned from these three sources helped the team improve the GC courses with initiatives on multiple fronts, such as revising the course shell, while simultaneously developing and refining systems of orientation for course instructors. By revisiting the guiding

question multiple times, the team was able to make evidence-based decisions and iteratively improve the courses until a stable design and facilitation approach was achieved.

DEVELOPMENT PROCESS: PILOT, ITERATION, AND SUSTAINABLE SYSTEM

The program’s system for course development, structure, and facilitation changed over time based on team analysis of data sources described in the previous section. The project unfolded in three phases: “Phase I: Pilot” (including challenge project design), “Phase II: Iteration,” and the development of a “Phase III: Sustainable system and dissemination.” These phases supported ongoing course quality, instructor orientation, and sharing lessons learned with a wider audience. Based on insights derived from examination of data from the pilot, changes were made in both the people tasked with course building and facilitation, as well as the addition of a system of support for facilitator orientation. Figure 3 illustrates these phases.

Figure 3. Timeline of course iteration phases



In the following section, each phase will be described, followed by a discussion of the insights gained through evidence-based reflection on data sources. Some insights were derived from the examination of work samples and course observations, while others were gleaned from student surveys and instructor reflections.

Phase I: Pilot

Challenge project design

Over the summer of 2020, in consultation with learning experience designers with expertise in project-based learning, select Northeastern faculty were commissioned to generate challenge projects grounded in their current research. It was agreed that these faculty would be available to consult with instructors as students worked on the projects, but the commissioned faculty were never intended to facilitate the courses.

While some faculty had previously developed courses that included projects, none had ever developed a project-based course whose sole focus was engaging students in a response to a defined challenge. Leveraging provided templates and support, the faculty authored project “blueprints” that included the following core components of a course challenge:

- Challenge problem title
- Driving question
- Informal videos (see description below)
- Need-to-knows (key understandings students would need to develop)

- Resources (library of curated sources that students could access to develop key NtK understandings)
- Scaffolding activities
- Description of student team deliverable(s)
- Evaluation criteria

The completed blueprints detailed the significance of the problem. The faculty also recorded compelling videos to explain the origins of their research interests. Their shared stories sometimes included highly personal experiences, such as systemic injustices they experienced in childhood that motivated them to pursue their areas of research. Some courses also included video interviews with additional faculty across several disciplines to provide multiple perspectives on the challenge. Sample project challenges included:

- Antibiotic resistance: Who should be involved in the funding and production of safe and effective novel antibiotics to overcome bacterial drug resistance, and ensure that the health of the population is equitably protected from infections over time?
- Sustainable fisheries: How can industrial and artisanal fisheries (globally) be designed to simultaneously promote food security, the well-being of fishing communities, and the sustainability of coastal marine ecosystems?
- Immigration justice: How can we build a coalition that works to ensure immigrants have fair and just access to resources and opportunities related to a specific aspect of their life (such as housing, healthcare, employment, legal services, and education) in Boston?

Despite the specificity of each course's focus, students had significant agency and self-determination in how they approached the challenge. For example, project teams in the sustainable fisheries course were able to select any part of the world, type of fishery, and fish species to focus on when investigating their challenge. The diversity of focus and responses across teams helped emphasize the importance of contextual complexity; a viable solution for one fishing industry might not be advisable for others.

In addition to collaborating with faculty to design challenge projects, the team developed resources to orient students to the PBL process, including a module titled, "Introduction to team and real-world problem solving" and a project kick-off module focused on key tasks, such as forming a team agreement.

The Challenge Projects were developed over approximately eight weeks during summer 2020, leaving only about two weeks to implement the projects as courses in the learning management system (Canvas). Graduate students who had academic technology training created the online courses within Canvas, using the blueprint documents to put content into a course template that followed a conventional online structure (e.g., weekly outcomes, activities).

Pilot online course structure

The courses were full semester, 14-week courses containing modules of content and assignments. An orientation module was created for the first week of the courses, with explanatory text about project-based learning and a high-level visualization of the PBL project process (see Figure 4).

Figure 4. Fall 2020 PBL visualization



The second week included team kick-off activities. Thus, the student work in the first two weeks was structured in a way one might expect in a conventional online course. After that, the course site structure emulated the blueprint, as a series of modules centered on key concepts (the “need-to-knows”) and curated resources.

Most of the courses were facilitated by staff such as student advisors (who were experienced with teaching an “Introduction to College” class), with the faculty who developed the challenges available throughout the semester for follow-up questions. The facilitators, however, received very little orientation to PBL, and, as indicated below, facilitators and students were uncertain about how to proceed after the first two weeks of the course.

Pilot: Reflections and insights

The guiding question provided a useful framework for judging the effectiveness of the Global Challenge course pilot: To what extent, and in what ways, can learning experience design, online structure, and facilitation support student PBL learning, teamwork, and a sense of connection with each other and the course?

From the outset, team members speculated that the typical structure and facilitation approach for online learning, such as a weekly modularized approach to content presentation, would be ill-fitted to PBL’s inductive pedagogical model, with tasks that typically span multiple weeks, and that a more process-oriented course structure would be needed to scaffold the learning experience. However, the tight timeline for course development did not allow for the creation of a customized course template prior to launching the pilot courses.

Finding 1: A learning experience design infrastructure that supports PBL challenge development is important

The blueprint template was extremely useful in scaffolding consultations with faculty prior to course development and as they designed their challenge projects. For example, the blueprint format ensured alignment between expectations for student knowledge development and resources provided in support of that knowledge acquisition. It also ensured consistency across courses, that all components in a global challenge were included.

For most faculty, the blueprint alone would not have been sufficient for them to develop a compelling challenge suitable for a first year undergraduate PBL experience. This is likely because the PBL process of engaging students in inductive learning was a new concept for the faculty charged with developing the challenges. These faculty were more accustomed to recording content-oriented

lectures than they were to recording videos in which they shared why they found the challenge to be an important problem to solve. Faculty were also new to the concepts of grounding challenges in as-yet unresolved questions, taking a backward design approach to consider what students would need to know to address those questions, and curating a collection of resources that students could use as they addressed their “need-to-knows” through inductive investigation of curated literature. Individual consultations between a PBL expert and the faculty, using the blueprint as a means for documenting the challenge project development, was key to developing challenges grounded in PBL pedagogy.

Finding 2: Design supports for challenge development are necessary, but not sufficient

The pilot was developed over one summer, and courses were staged in the university’s standard template for online courses. The team suspected that a conventional online course structure might not “work” for online PBL learning but hoped that the blueprint documents would at least help suggest a course architecture. In reviewing comments from student surveys and talking with course facilitators at the conclusion of the fall 2020 semester, it became very evident that the conventional online structure of the courses was not sufficient to scaffold online, inductive learning that spans weeks.

The first iteration of course architecture focused on the “need-to-knows” and related resources, a structure built around course content rather than the PBL process. The development team anticipated that after two weeks of orientation, students would know how to apply what they had learned about PBL to their own teamwork on their GC project. While students reported gaining self-directed learning skills, they also indicated that front-loading the orientation was not sufficient and that they would appreciate more strategic support. Sample student survey comments included: “For the specific research steps, though they are listed clearly on the syllabus, our group somehow still lost direction,” and “I think the course does well to guide us to the work especially with the need-to-knows but I felt it was a bit different than I’m used to in that it has less structure.” The last comment is particularly interesting because it indicates that the student knows this is a different approach to learning, even respects it as an approach, but still encounters difficulties working in a less structured environment.

In retrospect, the development team realized that while the blueprint was extremely useful for consultation with faculty on the development of a challenge, the team also needed to develop an online course structure within the learning management system that supported PBL-informed student learning and instructor facilitation. The team resolved for the next iteration, in spring 2021, to develop a course architecture that would support PBL’s inductive process across the entire semester, not just in the first few weeks.

Finding 3: Course facilitator mentoring in online PBL pedagogy matters

The final dimension explored in the guiding question was that of facilitation. Student comments from fall 2020 expressed a desire for more instructor presence, as indicated by the following quote from a student survey: “[I would appreciate the] instructor providing us some insights of where to start and monitor our progress throughout the entire process.”

The PBL approach to learning was new for instructors as well as for learners. The development team speculated that a companion instructor orientation program might help address that need, in addition to revisions to the course proper. Instructors reported difficulty knowing how to work with students after the first three weeks of structured coursework transitioned into open-ended inductive PBL learning within student teams. These instructors needed to foster a sense of connection and community online, help student teams develop well-scoped responses to the course challenge, and

respond effectively to problematic team dynamics. On top of these significant responsibilities, it was important for the instructors to facilitate in a manner conducive to PBL that did not interfere with students' self-determined, inductive learning process. Below is a discussion of the iterative improvements to both course structure and instructor preparation to facilitate online PBL learning.

Phase II: Iteration

Findings from the pilot phase indicate the program had developed a successful process for working with faculty to design challenges (the problems students would grapple with in each course) but that the course structure and facilitation did not adequately support students in their PBL process. Below is a description of how the development team responded to those findings.

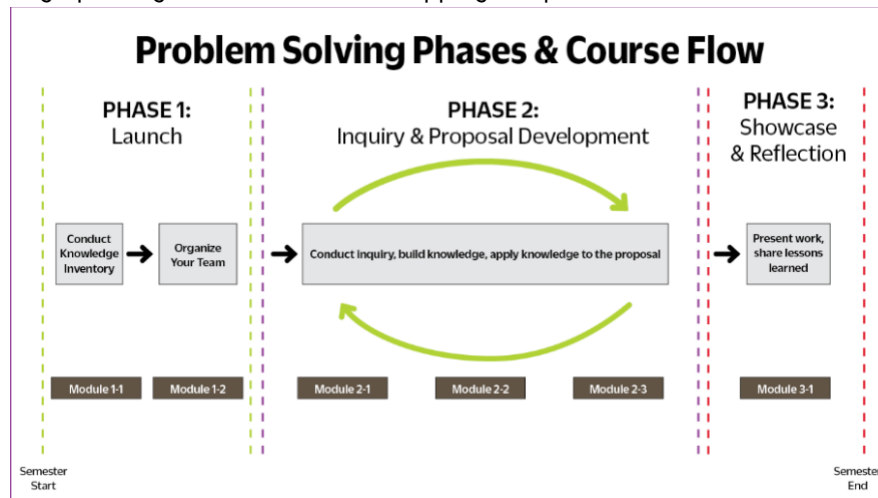
Course structure revisions

The development team significantly revised the Global Challenge online course structure and visualizations to make the PBL process more explicit, highlighting that each module in the course aligned with a phase of the PBL process. The original visualization in the pilot blueprint-structured courses included images that were largely decorative and did not contribute to student understanding of the PBL process. For example, it was assumed that learners would be able to infer what was involved in online teamwork by viewing images of people gathered around a computer in the “inquiry and iterative development” phase of the PBL process. The research of Clark and Mayer (2016) indicates that decorative and representational imagery often detracts from meaning-making in multimedia because the imagery places an extraneous load on the viewer that is not germane to the topic.

The revised PBL visualization included in the spring 2021 course focused student attention on the phases of PBL, learning activities that would take place in each phase, and what weeks of the course would be dedicated to each phase. The revised visualization was used as a graphic organizer throughout the course, highlighting each phase of the PBL process in the corresponding course modules (compare Figures 5 and 6).

Figure 5. Original course visualization with extraneous images



Figure 6. Revised graphic organizer visualization mapping PBL phases to course structure

The course architecture was also revised to support project work. For example, it was structured as six modules in Canvas, each of which corresponded to the PBL phases, with activities and prompts that guided each phase. The modules varied in duration, depending on the work required.

The course template scaffolded student work, both individually and in teams, and helped guide instructor facilitation (e.g., peer and instructor iterative feedback). For example, items such as team agreements and practice activities were introduced when needed, instead of at the beginning of the course. Rubrics and grading schema and the course facilitation plan were also revised and made more explicit. For example, instructors were advised to wait until after the add/drop period before forming the project teams.

Student survey responses indicated that this additional structure helped facilitators, and the comments also indicated that the additional structure did not distract from Global Challenge's goals for building learner self-direction and capacity to work in teams. Student survey responses indicated that the revised structure helped students have a better sense of what was expected of them, and that they were able to form mutually supportive relationships within their teams: "I never struggled to know what was expected of me assignment wise or to locate said tasks. I really liked the module organization"; "The project plans and assessments helped our group check in with each other about what we want to accomplish and how"; and "I think it would be significantly more challenging if I had had to work alone but since we worked in groups, bouncing ideas and information off of each other helped to solve the complicated ideas."

In addition, students' comments indicated a strengthened sense of connection with peers from other teams and with the instructors: "The instructor did a good job at communicating and giving back feedback which helped our project"; "Peer feedback was incredible. Also, the instructor gave us written feedback and notes over Zoom which was also very helpful."

Even when teams encountered difficulties, survey responses indicated that the self/peer feedback structure within teams was useful: "According to the feedback from my professors and team members, I am more clear toward my disadvantages and qualities that I can improve. They can also provide me some useful suggestions on how to conquer these disadvantages."

Instructor orientation program

In spring of 2021, Northeastern leadership hired doctoral students to serve as instructors for the Global Challenge courses. These graduate students were called the Project-Based Teaching Scholars (PBT Scholars). The development team created a 25-hour program that oriented scholars to PBL and online teaching. The orientation began several weeks before the semester's start and extended into the first third of the course to provide mentorship during the teaching experience.

Prior to the semester start, PBT scholars read seminal works about PBL and online teaching, engaged in activities where they viewed their courses from the student perspective, role-played doing course activities as students, and customized their courses to include instructor welcome videos and other enhancements. After the semester began, the PBT scholars regularly met with the development team over Zoom. In addition, each PBT scholar was assigned a mentor who would observe the course and check in with the instructor on a regular basis.

Extending the orientation into the first few weeks of class provided an opportunity for the development team to mentor the PBT scholars as they facilitated the courses for the first time and for the scholars to meet as a cohort to share challenges and insights. The following journal reflections of two PBT scholars indicate the orientation and mentoring was successful in helping them gain confidence in facilitating PBL's inductive learning process:

Before beginning in this program, I had not really heard of problem-based learning (PBL) . . . I did not really consider that there was so much that could go into it from both the student and the instructor sides. I have come to realize that it takes a lot of preplanning and thought from the side of the instructor to carefully craft a question and activities that will guide the students along but not necessarily direct them to the solution.

Teaching a PBL course is more about being a guide/facilitator to student learning than being the kind of knowledge gatekeeper that traditional classrooms often set us up to be. In my other undergraduate teaching experiences, the emphasis has been almost entirely on the content and student learning around the substance of the course and not HOW they are learning. I think my PBT Scholars experience has made me rethink how to combine these two aspects of both education and performance goals for students and myself.

Phase II iteration: Reflections and insights

The development team's interactions with PBT Scholars provided valuable information about how instructors were experiencing the course and the bottlenecks they were observing in student learning.

Finding 1: Directions and orientation materials need to be optimized for online learning

When role playing as students before the start of the semester, the PBT scholars noted that the courses were very text-heavy, and they felt overwhelmed. After the semester began, the PBT scholars observed that student questions indicated either they were not reading the text-heavy materials, or they were reading the materials but could not process dense information in that format.

Finding 2: Student’s inductive work with curated resources needs to be scaffolded

The PBT scholars also observed that students were not using the curated collection of resources as much as expected when addressing their need-to-knows. Those materials were in a module titled “Resources for Researching Your Global Challenge.” The development team speculated that this title implied that the materials were optional, not essential to the coursework.

Iterative improvements in response to findings

For the summer 2021 version of the course, the curated materials page was renamed from “Resources” to “Sources for Researching your Global Challenge” in the hopes this label would indicate the value of the contents. More substantively, an assignment was added to the first module of the course that required each student to annotate three of the source materials and post this information in a collaborative document, thus creating a joint annotated bibliography that could be relied on by all teams later in this course. In addition to driving the students’ attention to the source material, this assignment also provided practice in paraphrasing and citation, skills they would need to compose their proposals.

The development team worked with a multimedia design student at the university to develop a three-minute video orientation to online PBL that provided an overview of PBL as a process and how they would be learning online. This served as a counterbalance to the text-heavy portions of the course (see Figure 7 with video link below).

Figure 7. Screen capture from [Introduction to Project-Based Learning](#) video



With this second round of instructor-informed iterative improvements, the development team turned its attention to developing a sustainable system for offering the suite of courses. The team also considered opportunities to “go public” by disseminating its model for online PBL to a wider audience of educators.

Phase III: Sustainable system and dissemination

The final phase for the Global Challenge program was to formulate and formalize a sustainable system for building courses from course templates each semester. One learning experience designer established a model course for the overall program along with documentation and processes that could be followed by graduate students working for the academic technology group to build courses on a semesterly basis. This addition provided a scalable system for online PBL course deployment.

In reflecting on the lessons learned and resources developed for the Global Challenges program, the development team realized that the challenge design blueprint, course template, and instructor orientation program could be adapted for wider use. To promote the adoption of PBL across the university, the development team hosted a multi-day PBL institute in summer 2022, where participants used the PBL challenge design blueprint and the Canvas PBL course template to develop PBL courses for their students. In addition, the Canvas PBL template was made available to all educators, within the institution and beyond, through the Canvas Commons.

The following files are provided as open education resources for readers:

- PBL challenge course planning blueprint (see Appendix [here](#))
- Challenge course template for import into Canvas (see Files [here](#))

DISCUSSION

The development team's guiding question helped members reflect on systematically gathered student and instructor input and improve the course structure, facilitator support, and organizational systems for implementation across three semesters. This evidence-informed approach made it possible to progress from a pilot project to a sustainable system of online, project-based learning courses while remaining grounded in the project's goal to develop incoming undergraduate student capacity for PBL, teamwork, and a sense of connection.

Stoddard and Spanagel (2019) identify four challenges when engaging first-year college students in PBL:

1. Helping students choose a problem of appropriate size, scale, and scope.
2. Threading the needle, or urging students to contribute to existing knowledge without reinventing the wheel.
3. Keeping the ball rolling, or sustaining student interest and motivation in the research process and project.
4. Providing project structure and subtask scaffolding, while meeting individual team needs and promoting student creativity. (174)

Reflecting on these four challenges, the Global Challenge courses helped address the first challenge of scope by pre-defining a complex real-world problem for the students to work on, while also allowing considerable autonomy for students to identify the specific aspect of the problem they would address in their teams (e.g., how the problem manifests in a specific global location, population, or species). The courses addressed the second challenge, locating their work within preexisting knowledge, by including a curated collection of high-quality resources in the courses while also requiring students to seek out their own additional resources. When the development team realized that students were not sufficiently availing themselves of course resources during the pilot, they added an annotation exercise and renamed areas of the course to draw student attention to the curated collection. Motivation was largely addressed through course facilitation, specifically through engaged and frequent facilitator feedback. Facilitation was supported through instructor orientation and mentoring in PBL and online learning, and the course template itself prompted facilitators to provide feedback and key junctures in the course. The online course template also provided a thoughtfully scaffolded structure for tasks and subtasks, and the challenge guidelines provided students with the freedom to decide how they would creatively share their challenge response at the end of the course.

The following discussion elaborates on what we learned about how learning experience design, online course structure, and facilitation impact student experience in online PBL courses—including suggested implications for practice.

First, meaningful challenge problems drawn from faculty research provided motivating projects for students, even for those just entering college. Scaffolding materials, such as the challenge design blueprint, helped faculty develop their global challenges; yet, coaching from skilled learning experience designers was needed to develop projects for the unfamiliar PBL format. Likewise, the PBL approach was unfamiliar to instructors and students, and minimal materials were ineffective in helping them understand how to proceed in a PBL environment. Strong challenge projects are necessary for meaningful online PBL, but not sufficient for course success.

Second, a process-based online course structure that reinforced the PBL process was key to helping both students and instructors navigate PBL throughout the course. This structure supported inductive learning processes by walking students through the problem-solving process. It also prompted effective teamwork through exercises that supported iterative attention to planning and evaluating team functioning. In addition, the course template supported instructor facilitation of PBL by prompting them to provide feedback at key junctures. The design team wondered if or how the PBL process would be specifically useful to first-year and pre-matriculated students. Interestingly, students frequently mentioned specific aspects of PBL pedagogy in their survey responses: “[There were team building exercises] where we set rules that were needed to be followed at the beginning of the semester which made our ability to work together better as a team”; “Going through the Need-to-Know and research phases was really what allowed us to get enough information to put our project together”; and:

I had prior knowledge on this topic but after really going in depth with it, researching about the topic, and listening to other people’s points of view who are different than me and have other backgrounds really helped me learn and understand better.

Finally, providing professional development for course instructors enabled them to develop the facilitation skills necessary for supporting teams through inductive PBL learning. The development team learned that teaching the Global Challenge courses required subject matter expertise, an understanding of PBL as a pedagogical approach, an understanding of how learning takes place online, and the facilitation skills to provide feedback to teams on both project development and functional team development and maintenance. It is important to keep in mind that, following the pilot, all course instructors were graduate students who had little to no prior experience as instructors. Follow-up interviews illustrate how the orientation program and course design structure influenced their thinking about teaching:

What the training did was help me have a different mindset about feedback and think about my processes a bit differently than I had previously. I hadn't really thought about it before, but when I give feedback to a student, it's like an opportunity to get in some secondary teaching.

In some of the courses I've taken as a student, we had to deliver a product, but we had only one final submission of the project. There was no breakdown of the project into different parts or delivering the project in different milestones. I think it helps to have

different phases for the project and to provide the students with proper feedback so they can correct their mistakes and can improve the quality of their projects.

A separate study that examined the graduate student course instructors' experience revealed the significant extent to which they benefitted from the scaffolding of the online course template (English, Plews, Matthews-DeNatale, Simeon, Wilson, and Cheng, 2023).

As the elements of learning experience design, online course structure, and course facilitation evolved and matured across multiple semesters of the Global Challenge course offerings, the students' experiences with inductive learning and teamwork became more productive. One lingering question is the students' experience of connection. The Global Challenge courses were designed to help students develop a sense of connection with the institution and their peers. The challenges were grounded in Northeastern faculty research, and the PBL team-based assignment structure helped students develop a sense of connection with each other in the course. Students from the second and third cohort consistently conveyed that they developed strong connections with their team members and facilitators, but sometimes commented that their sense of connection to other students in the course was not as robust, as evidenced by the following three varied perspectives on the experience:

I really feel that Northeastern's project-based courses have made me come to like working as a team. I previously struggled with this, but I have significantly enjoyed the teamwork process.

I have definitely gotten to know my group members. We talk often about our work, but we almost always end up talking about our lives and ourselves too. I don't feel like I know the other students well at all, but that is okay.

Since we're working in groups to come up with a proposal together, we need to constantly contact to each other updating our ideas, moreover, not only did we work in our own groups, we also had a lot of connections with other groups exchanging our proposals to view the problem from multiple perspectives.

Interpersonal connections within groups seemed to be sufficient for students to form a gratifying sense of community in the course. How to develop a more pervasive sense of connection and institutional belonging across all students—or if that is even necessary for students to have an engaging and productive experience—is a question for further exploration.

CONCLUSION

Based on this research group's experience of systematically reflecting on the implementation of online PBL courses over multiple semesters, the following suggestions are offered for others who wish to undertake similar projects:

- Do not underestimate the change in mindset that is required to undertake project-based learning. The faculty engaged in designing the challenges, course facilitators, and students all need explicit explanations, scaffolds/templates, and coaching in PBL methods.
- Design an online course structure that supports process, helping students know how to leverage course content in response to PBL challenges. The architecture of the course, and

organization and labeling of materials, should signal and model essential elements of the PBL learning process. This helps students and facilitators know how to engage in PBL.

- While disciplinary knowledge is important, facilitation skills are key to successful PBL teaching, especially when providing feedback and managing teams. Because the PBL facilitation process is so important, embedding mentoring for new instructors while the course is underway can be very helpful, as it promotes instructor metacognitive development about their philosophy of teaching.
- The online course template can scaffold both instructor facilitation and student progress through the PBL process. As such, this approach can be an excellent way for graduate students—who likely have little experience as instructors, online course facilitators, and PBL pedagogy—to successfully work with pre-matriculated and first-year students.

The Global Challenges project required significant resources. These courses demonstrated the possibilities for engaging pre-matriculated and first-year students in PBL-based online learning, and Northeastern is currently expanding its fully online challenge-based offerings for this population across its global network, located in 14 cities across three countries. Hopefully this accounting of the model and lessons learned will be adapted by others to increase the quantity and quality of online PBL at their institutions.

AUTHOR BIOGRAPHIES

Gail Matthews-DeNatale, PhD (USA), is the senior associate director—faculty development for the Center for Advancing Teaching and Learning at Northeastern University. Her areas of specialization include online learning and qualitative research.

Laurie Poklop, EdD (USA), is a senior associate director for the Center for Advancing Teaching and Learning at Northeastern University. With expertise in online learning, her current work focuses on global student mobility and the future of learning with technology.

Rachel Plews, EdD (USA), directs the Center for Teaching and Scholarly Excellence at Suffolk University. She was formerly an associate director for the Center for Advancing Teaching and Learning at Northeastern University.

Mary English, PhD (USA), is a senior associate director for the Center for Advancing Teaching and Learning at Northeastern University. Her areas of specialization include learning design and project-based learning.

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