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TECHNOLOGY AND INQUIRY-BASED INSTRUCTIONAL METHODS: A DESIGN CASE IN STUDENT-CENTERED ONLINE COURSE DESIGN

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Although online course design is no longer new, few design cases describe the development of entire courses based on principles of student-centered learning design. This design case chronicles the context, design challenges, and successes and failures of a graduate course on Technology & Inquiry-based Instructional Methods for an online master's program in educational technology at a regional university in the southwestern United States.

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INTRODUCTION

Although online course design is no longer new, few design cases describe development of entire courses based on principles of student-centered learning design. Some articles in research journals offer design cases of units or modules within courses that are designed on principles of student-centered learning design (Lee & Ke, 2013), online training or professional development classes designed with a student-centered approach (Parchoma, 2003), or specific tools that promote student-centered interactions (Hu & Johnston, 2012). This design case chronicles the context, challenges, and product, as well as the design successes and failures of a graduate course on Technology & Inquiry-based Instructional Methods for a master's program in educational technology at a regional university in the southwestern United States. The course designer, who was the sole full-time faculty member for this program, also serves as the program coordinator and advisor. She also taught the course and authored this design case.

CONTEXT FOR THE DESIGN

This course was designed for an online master's program in educational technology (ETEC) at a regional university in a southwestern state. With few exceptions, students in the ETEC program are practicing teachers in K-12 schools across the state. All courses and other program requirements are provided online. Moreover, all courses in the program are offered in a compressed format: seven weeks in the fall and spring semesters, five weeks in the summer. This format allows students to complete two courses each semester while only taking one course at a time: one in the first, followed by another in the second sub term of each full semester. The student learning outcomes for the program expect that graduating students will be able to:

1. Develop a philosophy of educational technology that shapes their vision reflected in a variety of areas from the role of technology in personal and professional settings.

2. Utilize best research practices in order to make informed decisions regarding the effectiveness/impact of technology integration.
3. Demonstrate an effective integration of communication, media, information, and technological literacy skills.
4. Effectively design, develop, and integrate a variety of technological applications that are appropriate within professional settings.

To earn the master's degree, students complete 30 semester credit hours (10 classes) of required and elective coursework. This three-credit course was designed to be a program elective.

Initial Ideation

In developing the initial ideas for the course, I brainstormed with a director of technology in a K-12 school, who also serves as an adjunct faculty member for this program. She was not involved in developing the course, but provided expert, practical advice in identifying what knowledge, skills, and abilities are needed in the field. Having analyzed the inventory of courses in the program, we found an abundance of courses on technology tools, but few on instructional methods that are well-suited to designing technology-supported learning. As my brainstorming partner affirmed, schools provide technology training for teachers much more frequently than professional development on instructional methods on technology-supported learning. We immediately identified problem-based learning (PBL) as a potential focus for a new course. PBL is a well-documented method that has gained acclaim for providing authentic learning experiences that students find relevant and intrinsically motivating (Albanese & Mitchell, 1993; Jonassen & Hung, 2008; Jonassen, 2011; Norman & Schmidt, 1992; Prince & Felder, 2006). However, we decided to broaden the course topic to inquiry-based methods to introduce students to a wider array of instructional strategies than problem- or project-based learning alone, while still maintaining a strong focus on PBL within the course. We also thought that beginning with an examination of the key elements or characteristics of inquiry-based learning design and then contextualizing PBL within them would lead to a deeper understanding of PBL, as well as other inquiry-based approaches, such as case-based learning, discovery learning, and just-in-time teaching. The resulting course description and objectives follow:

This course examines the role of technology in inquiry-based instructional methods vital to fostering critical thinking and complex problem-solving skills and abilities. Emphasis is placed on social constructivist learning theories and inquiry-based instructional methods, such as case study approaches and problem- or project- based learning.

The learner will . . .

1. distinguish learning-centered instructional methods from teaching-centered methods and identify technologies that support each method type.
2. compare various inquiry-based instructional methods and discuss the role of technology in supporting and enhancing these approaches.
3. create a problem-, project-, or inquiry-based instructional design for a unit or lesson.
4. evaluate the instructional designs produced by peers and provide constructive feedback for enhancing the design.

The course description and student learning outcomes were reviewed through the university curriculum process and approved for course design and development.

Foundational Principles

PBL and other inquiry-based instructional methods, the content of the course, are derived from constructivist learning theory, which upholds the following primary principles:

- Learning results from a personal interpretation of experience
- Learning is an active process occurring in realistic and relevant situations
- Learning results from an exploration of multiple perspectives

(Richey, Klein, & Tracey, 2011)

In keeping with the course topic, course design followed a constructivist approach, particularly Jonassen's (1999) framework for the design of constructivist learning environments, as well as Savery and Duffy's (1995) criteria for problem-based learning environments. However, I also wanted to design a learning experience that challenged students' thinking about teaching and learning in an environment that supported open-minded inquiry, whether or not students subscribed to the epistemological foundations of constructivism. Moreover, I wanted to adhere to principles of grounded *student-centered* or constructivist learning environments and design an environment to "support learners as they negotiate multiple rather than singular points of view, reconcile competing and conflicting perspectives and beliefs, and construct personally-relevant meaning accordingly" (Land, Hannafin, & Oliver, 2012, p. 6-7). The four principles of student-centered learning environments (SCLEs) that Land, Hannifin, and Olliver (2012) offer are as follows:

1. The centrality of the learner in defining their own meaning
2. Scaffolded participation in authentic tasks and sociocultural practices

3. Importance of prior and everyday experiences in meaning construction
4. Learning is enriched via access to multiple perspectives, resources, and representations (p. 8).

My aim was to provide such an environment throughout the entire course, as opposed to a single or few modules, units, or activities in an otherwise teacher- or content-centered course.

DESIGN CHALLENGES

Designing a course on inquiry-based methods and adhering to principles of *student-centered* learning environments for online delivery in an accelerated format for non-traditional students presented several design challenges. I present the challenges here in brief and organize my description of the design of the course around these challenges in the next section.

Challenge 1: Selecting Content

Adhering to the first principle of SCLE design and in keeping with the nature of inquiry-based learning, I wanted students to have opportunities to select content that was meaningful to them and relevant to the learning environments that they design, yet I also needed to have some content as a foundation for discussion from which students could generate questions for their own inquiries. One of the challenges that I faced with this design was how to balance curating content for the course with giving students the opportunity to curate for themselves based on their own lines of inquiry.

Challenge 2: Deploying Methods

Land, Hannifin, and Oliver's (2012) second principle in the design of SCLEs calls for scaffolded participation in authentic tasks and sociocultural practices. With this principle in mind, I wanted to use inquiry-based methods in a course on inquiry-based methods and had no shortage of methods from which to choose. However, almost all the students in this program work full-time as teachers and often have work-related after school or evening events making synchronous activities unviable. Thus, another design challenge was how to create an authentic, problem-based learning experience that was online and asynchronous.

Challenge 3: Developing Dispositions for Open-Minded Inquiry

Graduate classes typically focus on cognitive domain content. However, oftentimes affective attitudes and beliefs influence cognitive understanding. Open-mindedness is one of many attitudes critical to inquiry and its sociocultural practice, as well as inquiry-based instructional methods My fourth challenge was how to help students develop the dispositions for open-minded inquiry in an accelerated online course that already had a great deal of cognitive domain content to be introduced, reinforced, and applied.

Challenge 4: Scaffolding a Design Problem/Project

The program for which this course was designed requires an electronic portfolio as the comprehensive exam for the program. Because we want students to develop artifacts for these portfolios in each course, the major assignment in each is a relevant project of some kind. In this course, the logical artifact would be an inquiry-based learning design. However, design problems are generally the most ill-structured of problem types (Jonassen & Hung, 2008). Thus, another design challenge was how to scaffold the process as students designed their inquiry-based learning projects.

Challenge 5: Developing Assessments *for* Learning

Assessments in post-secondary courses are typically those that are administered after learning has taken place and are intended to measure whether and how much learning has occurred. Although they take many forms (exams, quizzes, essays, research papers, projects), these are assessments *of* learning, in that we ask students to complete or produce them, and we evaluate what learning is demonstrated in or by them. Assessments *for* learning are those in which the student learns through the very process of completing or producing the assessment. My final challenge in designing this course was ensuring that all assessments in the course served as assessments *for* learning, rather than merely assessments of content knowledge attained. I felt that doing so applied the third and fourth principles of SCLE design.

COURSE DESIGN

After full development, the course resided in a typical CMS, with a landing page for a welcome and announcements that students see when they first enter the course. A left navigation menu listing the course weeks allowed to students to navigate to weekly resources and assignments. Clicking on each week displays a list of readings/viewing resources followed by a list of what students need to do, such as participate in a discussion, post an assignment, or provide a peer review. Table 1 is the "at-a-glance" course calendar that is included in the course syllabus with assignments and due dates for the 7 weeks of the course. This table is intended to offer readers an overview of the completed course while the remainder of this section details the decisions made to arrive at this overall structure and sequence.

WEEK	ACTIVITY	DUE DATES
1	Introductions	Post by Tues; welcome 3-5 classmates by Thursday
	Reading Discussion 1: Inquiry, Information Literacy, and Technology	Initial post by Thurs; replies to 3-5 classmates' posts by Sun.
	Book Selection Activity: Participate in book selection activity.	Initial 2-3 posts by Fri; additional posts as needed to select book by Sun
2	**Reading Discussion 2:** Elements of Inquiry-based Methods	Initial post by Thurs; replies to 3-5 classmates' posts by Sun.
	Continue selection of books and discuss format for **Book Review**	Post your preference for review format by Wed. Book review due in Week 4
3	**Reading Discussion 3:** Types of Inquiry-based Methods	Initial post by Thurs; replies to 3-5 classmates' posts by Sun.
	Continue work on **Book Review**	Due in Week 4
4	Post **Book Review** in forum for Reading Discussion 4.	By Thurs
	Reading Discussion 4: Problem-based Learning	Initial post by Thurs; replies to 3-5 classmates' posts by Sun.
	Begin **Design Project**	Due in Week 6
5	**Reading Discussion 5:** Not all Problems are Equal	Initial post by Thurs; replies to 3-5 classmates' posts by Sun.
	Design Project Evaluation: Practice Exercise	Post individual evaluations of the 3 examples by Wed; work with team to achieve consensus scores by Sun.
	Continue work on **Design Project**	Due in Week 6
6	**Reading Discussion 6:** PBL and Teacher Beliefs about Technology Integration	Initial post by Thurs; replies to 3-5 classmates' posts by Sun.
	Complete **Design Project** and post in Design Project forum in Week 7	By Sun
7	**Reading Discussion 7:** I Used to Think . . . Now I Think . . .	Initial post by Wed; replies to 3-5 classmates' posts by Fri.
	Complete **Design Project Peer Evaluations**	Post evaluations by Wed.
	Submit final **Design Project** (may be modified from feedback received from peers)	Post final presentation to Design Project forum by Friday.

TABLE 1. Course calendar with assignments and due dates.

Course Topics and Sequence

As indicated previously, the initial idea was to develop a course on PBL, and although I ultimately chose to propose and develop a course in inquiry-based methods, I wanted a strong emphasis on PBL because of the longevity, breadth, and depth of the research and practice on this particular inquiry-based method. While I determined that roughly half the course should be dedicated to PBL, I quickly discovered that it wasn't feasible in a 7-week course to allocate this "half" by a chunk of weeks in the first, middle, or last part of the term. Because we needed to cover some ground on inquiry-based learning design, we could not dedicate the first half of the course to PBL. However, students had a design project that would be due at the end of the course, and a PBL design needed to be among their options, so exploring PBL could not wait until the end. Even dedicating the middle weeks to PBL with other content before and after would not leave them enough time to develop their design projects after completing a stretch of weeks on PBL. I found that instead of allocating by weeks, I had to dedicate approximately half of each week to PBL throughout the 7 weeks of the course.

Once that decision was made, I realized I had a similar "time" problem within each week. It did not make sense to dedicate the first half of the week to any given topic and the second half to PBL, or vice versa. Instead, I conceptualized learning work for each week as "In Class" and "Outside of Class" with "in class" activities being those that involved actions and interactions in the online course space while out of class activities

did not. Examples of "in-class" activities are accessing the content resources for each week, participating in weekly discussions, collaborating in a PBL activity, and providing peer reviews (much more detail on each of these activities later). Out of Class activities did not take place in the CMS and included reading a selected book on PBL, preparing a book review, and developing an inquiry-based learning design. Thinking about student work this way made it easier to develop a single set of resources and list of activities for each week that allowed foundational learning on both inquiry-based methods and PBL in the first few weeks of the class. During these critical early weeks, we could explore inquiry-based learning design "in class," while students did some individual exploration of PBL outside of class.

Resolving that issue, selecting and sequencing topics for each week was straightforward. Because information literacy is a key outcome for ETEC programs, one of the International Society for Technology in Education (ISTE) Standards for Teachers, a critical 21st Century skill, and an outcome fostered through inquiry-based methods, the course began with "Inquiry, Information Literacy, and Technology as the first week's topic. The remaining weeks moved from general principles of inquiry-based learning design to PBL following the sequence of topics listed below in weeks two through six:

2. Elements/Characteristics of Inquiry-based Methods
3. Types of Inquiry-based or Inductive Teaching Methods
4. Problem-based Learning
5. Differing Problem Types and Scaffolding Problem Solving
6. PBL and Teacher Beliefs about Technology Integration

The "topics" for the last week of the course were peer review of student Inquiry-based Learning Designs and a final reflection on learning in the course. Figure 1 shows the weeks and topics. Areas shaded in light gray denote PBL activities in and out of class. Medium and dark gray areas denote activities supporting other course and inquiry-based learning design topics to be described hereafter.

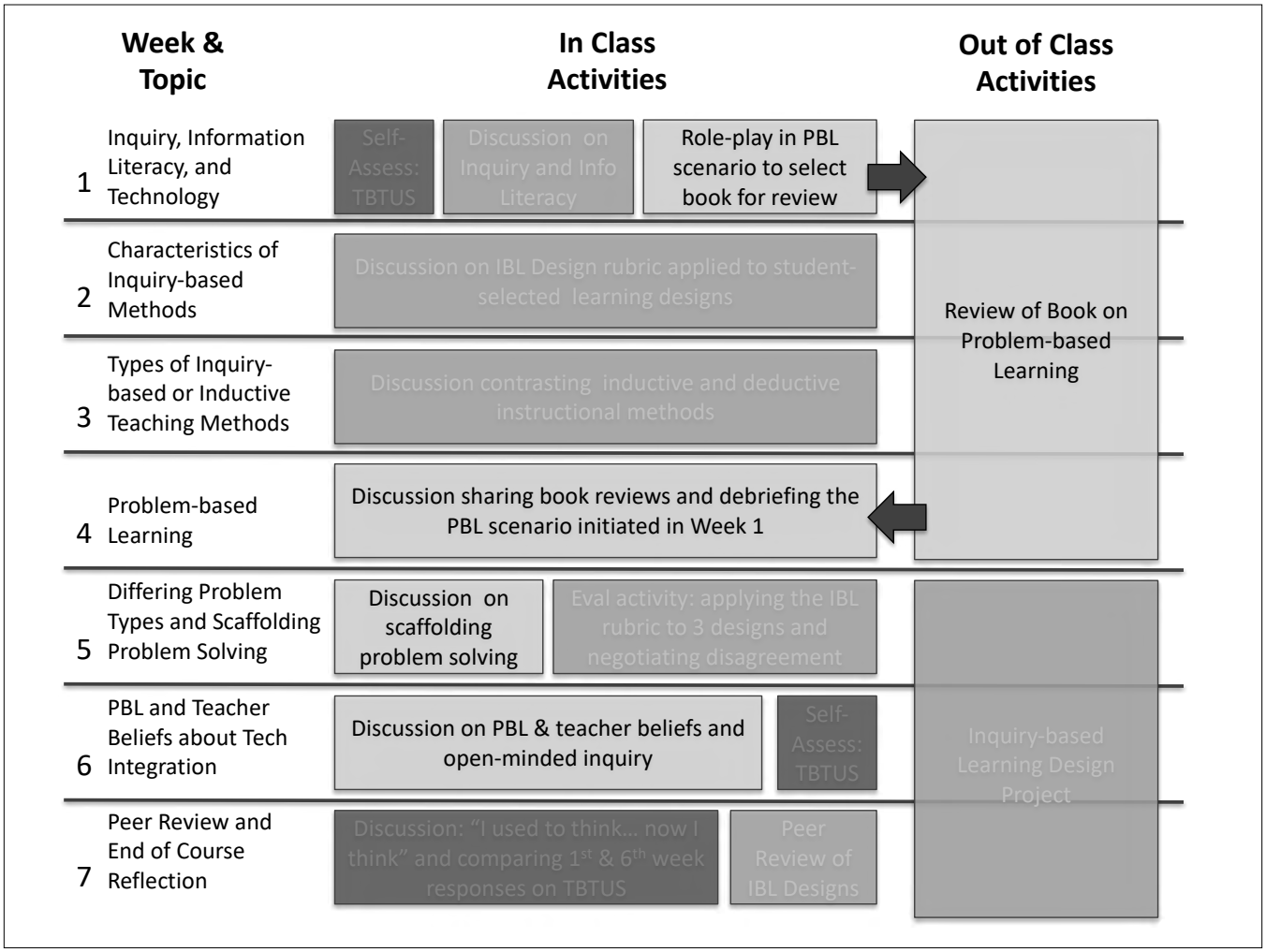

FIGURE 1. PBL activities throughout the course.

Challenge 1: Selecting Content

Having identified course topics, I moved to content selection or curation. When curating content for a course, I look first for publicly available resources in a variety of media formats (text, audio, visual, multimedia). I then consider periodical sources available through our library holdings. I typically only select and require students to purchase a book under one of three conditions:

1. content critical to the course is not available publicly or through the library holdings
2. the most authoritative source on a topic is published in a book
3. an affordable book that presents a variety of perspectives on a topic (typically an edited volume) is available and would be more convenient for students than keeping track of multiple websites, articles, videos, and other resources

I had located strong resources on characteristics of Inquiry-based Methods, including a rubric for evaluating inquiry-based learning designs on the public web (https://galileo.org/blog/rubric-for-inquiry-studies/). I also found periodical articles on types of Inquiry-based teaching methods, research on PBL implementations in many different settings, theoretical work on different problem types, scaffolding problem solving, and the impact of PBL on teacher beliefs about technology. Among these resources, I had plenty from which I could select as required content for the course or provide as a series from which students could choose. What I did not find among the resources on the web or periodical literature was a resource describing general tenets of PBL that were appropriate for graduate students in educational technology studying PBL design. Publicly available web resources provided overviews appropriate for professional development workshops, but not in the depth I was looking for in a graduate class. Periodical articles addressed various aspects of PBL in more depth, but not the fundamental principles or elements of PBL design.

However, in searching for books, I found scores of books on PBL: some tailored to PBL in K-12 education, some to specific levels (elementary, middle, or high school), others to PBL in specific disciplines or subjects, yet others on the research on PBL, PBL for differentiating instruction, PBL and 21st Century or digital age learning. This made selecting one book for all students a challenge. Although most students in the program are practicing teachers, they teach a variety of subjects at a variety of grade levels. Moreover, not all students are K-12 teachers; a few are in higher education or workforce training and development. To accommodate these diverse learning needs, I chose to make book selection an opportunity for students, which also supported the first principle of SCLE design (Land, Hannifin, & Oliver, 2012). I curated content for all the other course topics listed previously, but instead of selecting a text on PBL for them, I designed an information problem scenario that provided a context for finding, selecting, and reviewing a book on PBL. This move supported the second principle of SCLE design (Land, Hannifin, & Oliver, 2012).

Because students needed to discuss, select, obtain, read, and then review a book during the first 4 weeks of class, I limited additional reading and resources during these weeks to selections on The Big 6: Information and Technology Skills (www.Big6.com), Neil Stephenson's "Introduction to Inquiry-based Learning" website (www.teachinquiry.com), an article reviewing research literature on a variety of inquiry-based methods (Prince & Felder, 2006), and selected articles from the Foundation for Critical Thinking on elements of thought, inquiry, the role of questioning in teaching and learning, and distinguishing between inferences and assumptions (www.criticalthinking.org).

After presenting their book reviews in week four and debriefing the information problem initiated in Week one, the class took a deeper look into PBL over the next two weeks through in class discussions on differing problem types, scaffolding problem solving, and PBL and teacher beliefs about technology integration (as illustrated in Figure 1 introduced previously). Readings and resources for examining different types of problems and various means to scaffold the problem-solving process included Jonassen & Hung (2008) and Jonassen, (2011), along with selections on the assessment of thinking from the Foundation for Critical Thinking. The class examined the impact of PBL on teachers' beliefs about technology use by discussing Park & Ertmer (2007) coupled with Hare's "Glossary of Open-minded Inquiry," also from the Foundation for Critical Thinking.

Challenge 2: Deploying Methods

Although contextualizing book selection in a PBL scenario resolved one design challenge, it gave rise to another: creating an authentic, Problem-based Learning experience that is online and asynchronous. Other constraints to this challenge included time (the course was only 7-weeks) and tools readily available in the course management system (CMS). Although I frequently design course activities in tools outside of the CMS (such as blogs, wikis, word walls) for other courses so that students can experience technology resources that they might use in the learning environments they design, I didn't want to do so for this class for two reasons. First, the focus of the class was on the instructional methods rather than technologies even though they would choose technologies to support their design projects. Second, we were short on time in a 7-week class for an asynchronous PBL experience, let alone one that required students to develop familiarity with additional tools outside of the CMS. Given these constraints, I limited the PBL scenario

to one addressing an information problem—one in which the solution is finding, evaluating, and sharing information, rather than completing those tasks and then developing a solution based on them. The scenario provided an authentic, role-playing context for students to generate questions that needed to be answered, identify what information was needed, and select books that might provide answers. The product of this PBL experience was a review of the book.

So that the book reviews could be shared by mid-term, we needed to begin the PBL activity in the first week. Since the first week's topic addressed information literacy, it made sense to scaffold the PBL activity with Big6™, a widely used process for solving information problems and teaching information literacy. This gave students a process scaffold for the course activity and introduced them to information literacy content that they could use in their classrooms. The book review assignment description, an overview of the steps in the Big6™ process, and the PBL scenario were provided in a discussion forum in the CMS in the first week of class. The scenario or context for selection—intended to be vague and ill-structured—follows:

> *Following adoption of the ISTE (International Society for Technology in Education) Standards for Students, the Texas Education Agency (TEA) has assembled a delegation of educators (teachers, administrators, educational technology professionals, etc.) to explore problem-based learning as an instructional methodology for fostering those standards and skills. Each of you is a member of that delegation.*
>
> *Because of delegation members busy schedules, most of the team's work will take place online rather than in Austin. What the team needs to accomplish during the first week of service are the first three stages of the Big6™ process: task definition, information seeking strategies, and location and access. Use the forum below to further define the information problem, identify information needed, determine possible books (sources), select the best books, and identify who will review which books. Each delegate should review one book.*

This introduction also indicated that the team should decide on the format and substance of the reviews, along with the questions or criteria the reviews would be based upon. Playing the role of delegation leader appointed by the state agency, I offered some suggested formats and evaluation criteria:

- Edward De Bono's Six Thinking Hats
- Foundation for Critical Thinking's template for evaluating an article
- CRAAP test

Similar to using Big6™, this move allowed me to introduce students to additional information literacy resources that they might use with their students. Students discussed them as a delegation to select the best approach based on the group's shared definition of the information problem. Following this discussion in week one, they acquired their selected books and prepared their book reviews as an out of class activity over weeks two and three. They then presented their book reviews for "in class" discussion in week four. The discussion prompt for that week asked students to work through the last two stages of the Big6™ process, debriefing the problem and reflecting on the process.

Challenge 3: Developing Dispositions for Open-Minded Inquiry

Beyond the course content or the cognitive knowledge and skills targeted in the course, I also wanted to help learners develop dispositions or habits of mind for learning. Research suggests learning and thinking is not only a matter of having the requisite skills and abilities; affective values or dispositions for thinking and learning are equally important. Costa and Kallick (2008) describe these as "attributes that humans display when they "behave intelligently" and identify sixteen of these "habits of mind," such as listening with understanding and empathy, thinking flexibly, and questioning and posing problems. The Foundation for Critical Thinking (2013) labels them "valuable intellectual traits," which include fairmindedness, intellectual humility, intellectual empathy, and intellectual courage. Other conceptions include Ritchhart's (2002) notion of intellectual character and Deakin Crick, Broadfoot, and Claxton's (2004) idea of learning power. Although labels for these dispositions or habits vary somewhat in each conception, they all bear strong similarities, and all describe ways of "acting smart" or "behaving intelligently." Moreover, while all agree that these traits are "learnable," they are not developed by accident. Instruction, particularly the environment for instruction, must be intentionally designed to foster these dispositions. The challenge for me was that it just felt wrong to "teach" open-mindedness in any direct way. It seemed much more appropriate to create an environment, atmosphere, or mood that would foster those dispositions that are conducive to open-minded inquiry.

I want to define what those dispositions are by describing what they are not. Open-minded inquiry is not the uncritical acceptance of any idea as valid. Instead, it involves flexible thinking, a willingness to change one's mind when considering new evidence after critically examining its merits. It requires a degree of comfort with uncertainty: not an absence of conviction, but the humility that what is right or wrong or certain in one situation may not be in another. It also involves some risk-taking and perseverance, a willingness to make mistakes and learn from them rather than giving up too soon. What works against the open-minded pursuit of truth is the need for closure or certainty, dogmatism, rule-boundedness or rigidity, and fear of making mistakes (Hare, 2002, 2009, 2011). In addition to making an intentional effort to model open-mindedness in my interactions with

students throughout the course, I deployed three strategies to address this design challenge: a governing rule for student interactions, weekly quotations, and relevant humor.

Course Welcome

The first strategy for creating an atmosphere of open-minded inquiry was the "golden" or governing rule for student interactions. This rule and its rationale were introduced on the "welcome" or introduction page within the course management system (CMS) along with a friendlier or more light-hearted course description than the formal, catalog description provided on the syllabus. The description and governing rule follow:

> *An official description of this course, along with the learning objectives/outcomes, is provided on the syllabus. What I offer here is a description of what you will experience over the next several weeks. The key ingredients are a pound or two of readings (on information literacy, inquiry-based methods, and critical thinking), a smattering of provocative quotes, a dash of humor, several forumsful of stimulating discussion, and a tasty design project. Add salt and pepper (self-reflection and collaboration) to taste. The first four weeks of the course are heavier on reading and discussion than the last three, during which the heavy-lifting shifts to the design project, so the reading is lighter.*
>
> *In addition to this main dish, I also hope to create an ambiance or atmosphere in this course. We live in a world of uncertainty, doubt, complexity, and contradiction. Yet in too many contexts, we're required to be certain, confident, simplified, and consistent, lest we be judged stupid or flaky. I want this course to be a place where we can be uncertain and unsure without fear of such judgments. A place where we can be critically curious, receptive to new ideas or different perspectives, flexible in our thinking, and open to changing our minds. To create this atmosphere, I offer one rule to govern our interactions with each other. Always keep the following proverb in mind: "We drink from wells we did not dig; we are warmed by fires we did not kindle." And as others have added, "we profit from persons we do not know," and "we stand on the shoulders of giants." Recognizing how much there is to know and how much of it we owe to those who came before us, let's be humble about what we know and generous in sharing it with each other. Let's also be courageous in our questioning, particularly in questioning ourselves and our own thinking.*

Weekly Quotes

The second course element intended to inspire open-minded inquiry was a series of quotes provided with the readings and resources for each week. The design thinking behind this element draws upon the notion of "inspirational" or "motivational" quotes—pithy yet concise bits of wisdom typically taken from noteworthy and accomplished persons. Quotes for each week were relevant to the topics for the week, and tended to emphasize attitudes rather than content knowledge of the topic alone. Table 2 (next page) shows the topic for each week, the theme of the series of quotes, and a few example quotes from each series.

Relevant Humor

The final design strategy intended to foster open-minded inquiry was a weekly dose of humor. A great deal of scholarship is dedicated to exploring the impact of humor on learning. In this case, the humor was not only intended to make course concepts a bit easier to swallow, I also hoped that poking some fun at a few of the follies and fallacies that derail open-minded inquiry might provide a lesson or two for avoiding them. I also thought that creating an environment in which educational technologists could laugh at themselves and common mistakes or misconceptions might foster some intellectual humility—an ability to take our inquiries seriously, but our*selves* lightly. These offerings included a few articles and videos from *The Onion*, as well as graphics and cartoons from College Humor, PHDcomics.com, and elsewhere on the web. The humor offerings were related to the topic each week, just as the quotes were.

Challenge 4: Scaffolding A Design Problem/Project

The culminating activity for the course was an Inquiry-based Learning Design Project, which required students to develop an inquiry-based learning design unit for the subject they teach or aspire to teach. This requirement was intended not only to make the project relevant and meaningful to them, it also applies SCLE principles 1,2, and 3. However, as Jonassen and Hung (2008) note, design problems are among the most ill-structured of problem types. I felt that designing an inquiry-based lesson relevant to their own teaching area eliminated some of the difficulty inherent to design problems, such as analysis of users and needs, or consultation with subject matter experts as required for instructional design problems. Nevertheless, I still needed to provide scaffolds for thinking through and developing an inquiry-based learning design. Before I began seeking content for the course, I had only weak ideas on how I would do this. I knew I would provide some example designs—what Jonassen (2011) would label cases (or case studies). These cases could provide structural analogues, but I needed to find or develop a way to engage students in analyzing them so that their structures became apparent. Finding the Galileo Educational Network's Rubric for Discipline-based and Interdisciplinary Inquiry Studies was a stroke of luck in resolving this challenge. With the rubric to provide a structural scaffold, we could evaluate prior experiences, alternative perspectives, and analogous cases, which applies SCLE principles 1,3, and 4 (Land, Hannifin, & Oliver, 2012).

Early in the term (week two), I introduced students to the rubric, which describes the structure of an inquiry-based design: its elements and the criteria or standards for each.

CONTENT TOPIC	QUOTE THEME	EXAMPLE QUOTES
Inquiry, Information Literacy, and Technology	Information Literacy & Learning	"We are drowning in information, but starved for knowledge." ~ John Naisbitt "The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn." ~Alvin Toffler
Elements of Inquiry-based Methods	Questions & Questioning	"Judge a man by his questions rather than by his answers." ~Voltaire "The scientist is not a person who gives the right answers, he's one who asks the right questions." ~Claude Lévi-Strauss "The uncreative mind can spot wrong answers, but it takes a very creative mind to spot wrong questions." ~Anthony Jay
Types of Inquiry-based or Inductive Teaching Methods	Inquiry & Inquiring	"As it is, the lover of inquiry must follow his beloved wherever it may lead him." ~ Plato "Beyond all sciences, philosophies, theologies, and histories, a child's relentless inquiry is truly all it takes to remind us that we don't know as much as we think we know." ~Criss Jami
Problem-based Learning	Problem-solving	"If I had an hour to solve a problem I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions." ~Albert Einstein "A problem well put is half solved." ~John Dewey "It's so much easier to suggest solutions when you don't know too much about the problem." ~Malcolm S. Forbes
Differing Problem Types and Scaffolding Problem Solving	Confronting Difficulty/ Challenge	"Many of life's failures are people who did not realize how close they were to success when they gave up." ~Thomas A. Edison "Just because something doesn't do what you planned it to do doesn't mean it's useless." ~Thomas A. Edison
PBL and Teacher Beliefs about Technology Integration	Teaching & Technology	"In a world of change, the learners shall inherit the earth, while the learned shall find themselves perfectly suited for a world that no longer exists." ~Eric Hoffer "Much education today is monumentally ineffective. All too often we are giving young people cut flowers when we should be teaching them to grow their own plants." ~John W. Gardner "Any teacher that can be replaced by a computer deserves to be." David Thornburg
Peer Review of Inquiry-based Learning Designs	Innovation, Imagination, & Intelligence	"The true sign of intelligence is not knowledge but imagination." ~Albert Einstein "Keep in mind that imagination is at the heart of all innovation. Crush or constrain it and the fun will vanish." ~Albert-László Barabási

TABLE 2. Themes and example quotes.

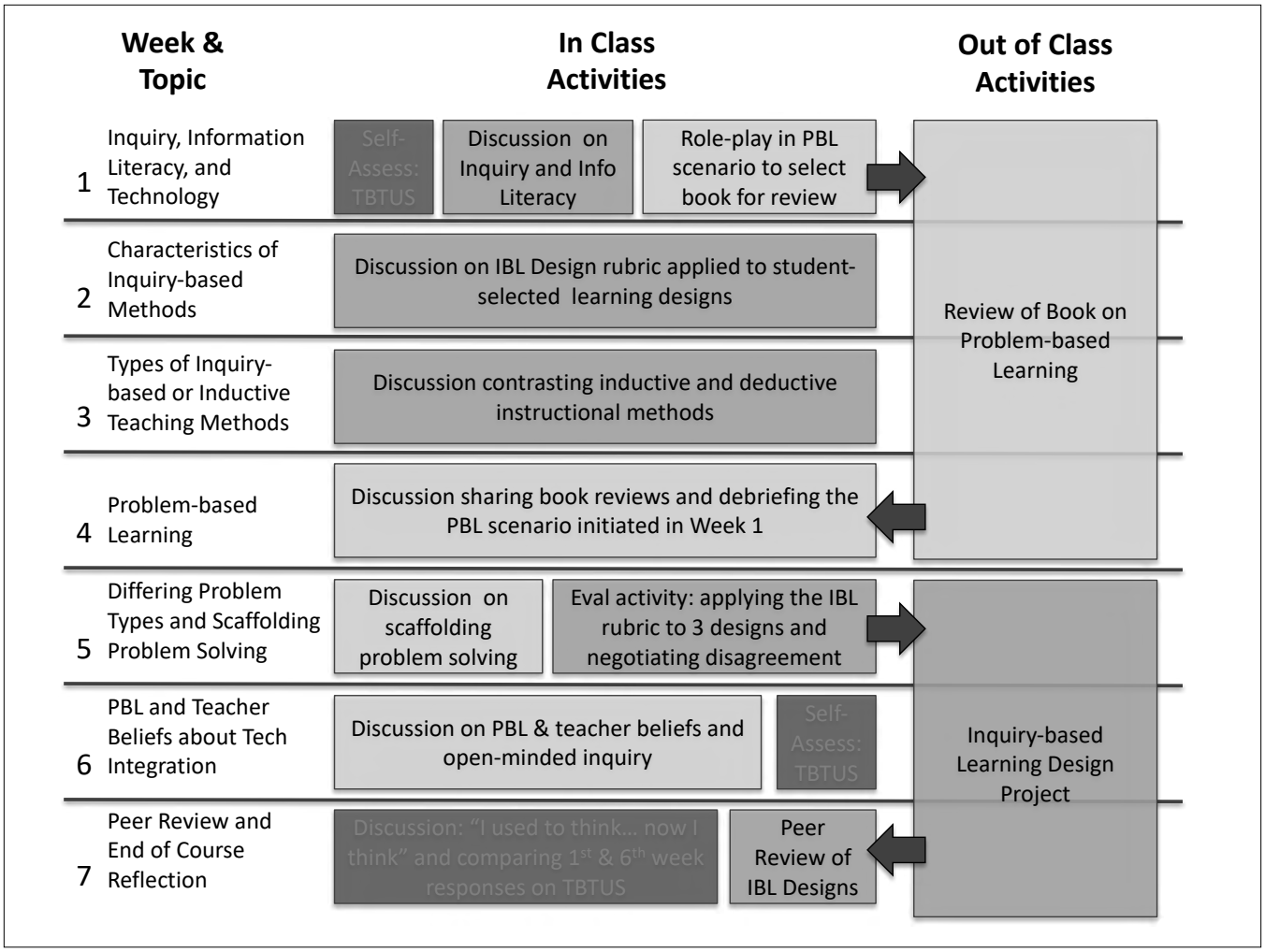

FIGURE 2. Scaffolds for Inquiry-based Learning Design.

In the week two discussion, students were asked to apply that rubric to their own or a self-selected lesson, and shared/discussed results with the rest of the class (SCLE principle 3). In doing so, they tapped into their prior experiences and gained some alternative perspectives—others' views on their design and new views/ideas from looking at the designs of others (SCLE principle 4).

Later in the term (week five) in a practice evaluation activity, they then applied the rubric again, this time to analogous designs/cases, in order to further examine the structures or *schema* of this specific type of design problem (inquiry-based learning designs). I carefully selected the analogous designs to reflect different degrees of Inquiry-basis—low, moderate, and highly inquiry-based. From applying the rubric, comparing assigned scores with other classmates, and negotiating differences or conflicting interpretations, I hoped that students would develop a deeper understanding of the elements of inquiry-based learning design and from doing so, develop their own process and design product. This activity also applies SCLE principles one and four. Figure 2 shows these and other course activities scaffolding students understanding of inquiry-based learning design in medium gray.

Challenge 5: Developing Assessments FOR learning

Developing assessments for (rather than of) learning was perhaps a self-imposed challenge. However, I felt that doing so is in keeping with best practices for the assessment of thinking and learning in general, as well as in inquiry-based learning designs and SCLEs more specifically. I wanted to provide a variety of opportunities to provide students with feedback, as well as reflection on learning. The primary course activities, weekly discussions and two problem- or project-based assignments, provided most of these opportunities. Table 3 lists all course activities and how they were weighted in calculating students' course grades. Developing assessment measures for these activities that supported learning was the challenge, even if it was self-imposed.

Each of these activities involves varying thinking moves or intellectual skills, and were intended to provide a combination of opportunities for learning with others and learning

ASSESSMENT/ACTIVITY	WEIGHT
Reading Discussions	30%
Book Review	20%
Design Project	30%
Peer Evaluations of Design Projects	10%
Course/Eportfolio Reflection	10%

TABLE 3. Course assessments and grade weights.

alone. I wanted the evaluation rubrics for each to align with the intellectual work or learning involved with each activity, not merely list the qualities or characteristics expected in a finished product, such as a post in a discussion or a review of a book. The Association of American Colleges & Universities (AAC&U) has identified core intellectual skills and abilities for undergraduate education, such as critical and creative thinking, ethical reasoning, teamwork, and problem solving. Called the VALUE project (Valid Assessment of Learning in Undergraduate Education), the effort involved assembling teams of faculty from colleges and universities around the United States to develop rubrics for assessing these intellectual skills (AAC&U, 2014). These rubrics articulate fundamental criteria for each intellectual competency, with performance descriptors demonstrating progressively more sophisticated levels of attainment from "Benchmark" or *beginning* to "Capstone" or *accomplished*. These rubrics were developed in order to "position learning within a basic framework of expectations" using a "common dialog and understanding of student success" that is "shared nationally" (AAC&U, 2014). Although the rubrics are designed for assessment of undergraduate education, the highest levels of attainment represent the expected competencies of those who have completed an undergraduate degree and thus can appropriately be expected of graduate students. I selected and adapted criteria from these rubrics to develop assessment measures for most course activities. I then presented the rubric with each activity or assignment description for students to refer to as they engage in the activity or prepare the assignment. Doing so doesn't merely show them what they will be graded on; it shows them what thinking or learning moves they should engage in as they participate in the activity or work on the assignment.

Assessment Measures

Since weekly discussions of readings and resources required students to make an initial post responding to a prompt, as well as post replies to classmates' posts, the rubric for evaluating their participation in discussions included criteria pertaining to written communication and to constructing knowledge with others. This rubric adapted criteria from four VALUE rubrics, as follows:

- **Purpose and Context** from the "Context of and Purpose for Writing" criterion on the Written Communication rubric
- **Individual Contributions** from the "Individual Contributions Outside of Team Meetings" criterion and **Facilitates Contributions of Others** from the "Facilitates the Contributions of Team Members" criterion on the Teamwork rubric
- **Learning from Others** from the "Diversity of Communities and Cultures" criterion on the Civic Engagement rubric
- **Taking Risks** from the Creative Thinking rubric

Although prompts varied each week, the **Purpose and Context** criteria addressed how well a student composed posts that were relevant to the discussion prompt, while the **Taking Risks** criteria encouraged seeking out or following through on "untested and potentially risky directions or approaches to the assignment." The remaining criteria related to the intellectual skills involved in co-constructing knowledge in dialogue with others.

The Book Review assignment involved more critical and evaluative thinking, including examining the contents or information presented in relation to the research questions posed. This rubric adapted criteria from four VALUE rubrics, as follows:

- **Purpose** from the "Context of and Purpose for Writing" criterion on the Written Communication rubric
- **Explanation of Issues** and **Evidence/Analysis** (combines "Evidence" and "Influence of Context and Assumptions" criteria) from the Critical Thinking rubric
- **Conclusions** adapted from the "Application/Analysis" criterion on the Quantitative Literacy rubric
- **Access and Use Information Ethically and Legally** from the Information Literacy rubric

Although students submitted their reviews as an attachment to their initial post in a discussion forum, this rubric was used only to evaluate the book reviews. The rubric developed for evaluating weekly discussions was applied to student forum posts.

The evaluation rubric for the Inquiry-based learning design projects came from the Galileo Educational Network (2013) as described previously. I selected this rubric because (like the VALUE rubrics) it was developed by a team of persons who have thought deeply about key elements of inquiry-based instructional methods and thus had a degree of validity external to the course. The rubric details eight elements of inquiry-based learning design and offers one to three criteria for evaluating each element. The descriptors for each criterion move progressively from "beginning" to

"developing" to "emerging" to "aspiring" using a 4-point scale. Thus, the score ranges using this rubric are as follows:

- 0-16 = beginning
- 17-32 = developing
- 33-48 = emerging
- 49-64 = aspiring

Although students first encountered and applied the rubric in the second week of class, I also used the rubric when I introduced students to the Design Project assignment in week four. The presentation of this assignment included assignment instructions, example inquiry-based learning designs, along with the rubric and a forum to further discuss the appropriateness of each of the elements and criteria. I also prompted students to discuss the target score for earning an "A" on the assignment. I wanted students to identify a unit of instruction or lesson in their subject/grade that didn't seem to work very well, but that might reasonably be improved with an inquiry-based approach. Because characteristics of their learners, the learning objectives they were aiming to foster, and other factors would impact the degree to which the lesson should be inquiry-based, I didn't believe that students' designs needed to attain the high end of the "accomplished" range to earn an A. However, because it was a graduate level course on inquiry-based methods and because the ISTE Standards for Teachers and other standards demand it, I wanted to see students' designs go beyond the "beginning" level. I proposed a target score of 50 for this course assignment, with the following grading scale based on this target:

- A = 45–50
- B = 40–44
- C = 35-39
- D = 30-34
- F = 29 and below

Students discussed and agreed on the proposed target score.

Self-Assessment and Reflection

Each of the weekly discussions prompted students to reflect on their understanding of concepts from reading and resources. However, I provided three activities intentionally designed for self-assessment and reflection on attitudes or beliefs.

- **Teacher Beliefs about Technology Use Survey (TBTUS):** Because readings and discussion in week six focused on PBL and teachers' beliefs about technology use, including Park and Ertmer's (2007) study of the impact of PBL on those beliefs, I incorporated Park & Ertmer's TBTUS into the course as a self-assessment. Students completed the TBTUS in the first week of the course and again in the sixth week when exploring this topic. I then provided students with their responses from the beginning and 6th week of the class, along with the mean scores/responses of the whole class. Students then had the opportunity to reflect on and discuss any changes in their beliefs in their final reflections on course in week seven.
- **Week six Discussion on Open-minded Inquiry:** Another reading selection for Week six was Hare's Glossary of Open-Minded Inquiry, a "brief guide to the ideal of open-minded inquiry by way of a survey of related notions," published by The Foundation for Critical Thinking (www.criticalthinking.org). As Hare explains in the introduction, the aim of the glossary is "to offer teachers an insight into what it would mean for their work to be influenced by this ideal, and to lead students to a deeper appreciation of open-minded inquiry." The week six discussion prompt asked students to select 3-5 terms or "notions" from the glossary and reflect on whether or not their learning/study of PBL and other inquiry-based methods in the course had an impact on their own beliefs or values as defined in the traits/ terms they selected.
- **Final course reflection:** The final discussion in week seven asked students to reflect on how their thinking changed from the beginning to the end of the course. The Project Zero (n.d.) thinking routine "I used to think…; Now I think…" prompts learners to reflect on something they knew, felt, or believed in the past and articulate how their understanding has changed with new knowledge, perspectives, or experiences. For purposes of this class, students were to focus on thoughts related to the content of this course (technology and inquiry-based methods), and "Used to" was defined as before this class began. Students were also prompted to feel free, but not obligated, to share changes in their thinking revealed by the TBTUS self-assessment completed in Week's 1 and 6. They were also invited to comment on whether or not their learning in the course facilitated any development of the Valuable Intellectual Traits identified by the Foundation for Critical Thinking, which was the single assigned reading item for the week.

The prompt for the week six discussion also asked students to identify (if they could) any specific components of the course (articles, weekly list of quotes, book review project, reading discussions, design project, example designs, design project rubric, humor offerings, the intended "atmosphere" for the course) that may have contributed to changes they perceived. Figure 3 (next page) shows activities related to self-assessment and reflection in dark gray.

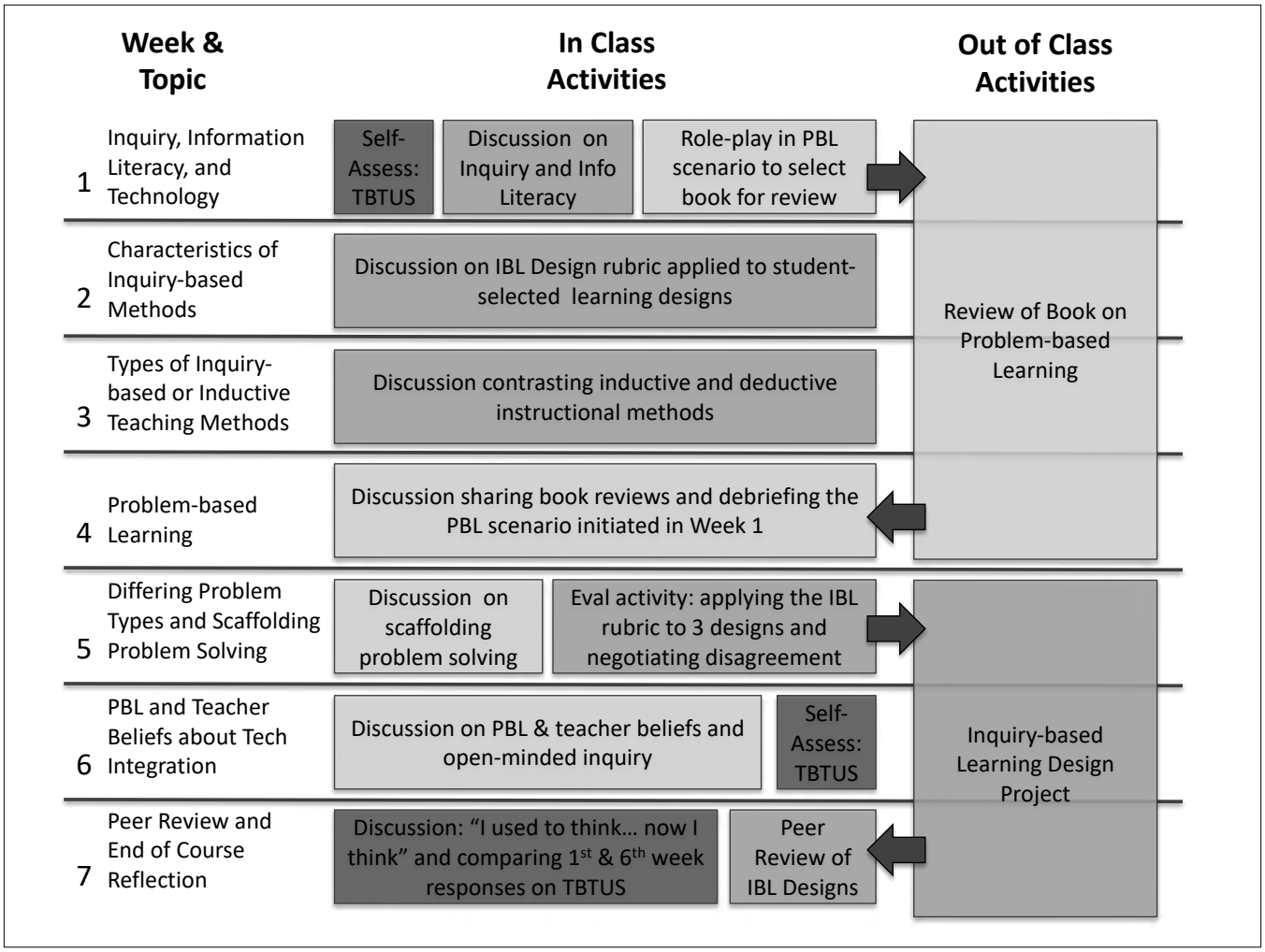

FIGURE 3. Self-assessment and reflection activities.

SUCCESSES AND FAILURES WITH THE INAUGURAL OFFERING

The course was offered for the first time in the second 7-week subterm of a fall semester. Although most activities went as planned, there were a few unforeseen issues with the course design and the student experiences in it.

Class Was Too Small

In a course designed on principles of constructivism, its crucial to have enough students to present varying perspectives, so that they can socially negotiate and construct meaning. Weekly discussions of readings and resources were one of the staple activities of the course design intended to support knowledge construction and meaning making. Although the "rules" for participation were intended to be rather flexible (initial post by Thursday; 3-5 replies to classmates' posts by Sunday) in order to accommodate the varied schedules and commitments of students in the class, too many students waited to make an initial post on Friday or Saturday, an action which was confounded by the very small class size (8 students). The result was that true "discussion" floundered throughout the term when 3-4 students habitually made an initial post on Friday, and all of their required replies late Sunday night. In a class of 12 or more students, when 3-4 students participate in such a way, the discussion does not suffer as much as it does in a class of 8.

However, decreasing the flexibility in the rules for participation—for example, requiring students to make their 1st post by Thursday, 2nd post by Friday, 3rd post by Saturday—in order to compel more of a "discussion" seems considerably less "student-centered" and much more "teacher-directed." Critics of online learning—particularly those that argue against online courses on the grounds that they aren't or can't be "student-centered"—would likely be the first to point out that such rigid prescriptions are necessary, failing to recognize in such assertions that it's the very affordances of asynchronous discussions that make such "rules" possible. The brick-and-mortar parallel for a 55-minute session of a face-to-face class would be to mandate that each student contribute a comment in the first 20-minutes of class, make another comment in middle 20-minutes, and a third in the

last 15. In such a design, true "discussion" does not occur either, unless the class is very small. However, if the class has 20-25 students, what happens is the battle to simply insert some comment in the allotted timeframes—no matter how insightful or even relevant it might be. Such rules inhibit "discussion" as much as they facilitate "participation." The benefits of asynchronous, online discussions are that every student gets a chance to speak and gets a chance to think through ideas and concepts before doing so. These affordances better support learners in constructing personally relevant meaning; however, it is a challenge to negotiate multiple points of view and reconcile competing perspectives when too few perspectives are offered or are offered too late in the discussion.

I addressed this issue with two strategies. The first was discouraging late initial posts and replies in the evaluation/grading of individual students' participation and providing corrective feedback early on. After the first two weeks, participation in week three was much better. However, in the week four discussion, a few students reverted to late initial posts or making all posts on one day. To address this, I announced the need for timely posts in a class of this size. All students in the class responded to announcement, either in the Q&A (question and answer) forum in the class or by private email to me. From these responses, it was clear that discussion participation was not due to a lack of engagement or enthusiasm for the course and course contents; nor was it a lack of discipline or self-regulation. It was simply very busy lives outside of class. More rigid rules governing participation would not correct it—each student knew precisely how much a late post or two would affect their overall grade and weighed that into their decisions to meet other demands. They knew that the benefit others would receive from their posts would suffer, and they knew that their own scores would suffer, but they simply had to meet external demands from work, family, and other sources first.

Scaffolds For Consensus Building

Another issue in the course was students' reluctance to negotiate meaning/interpretations or build consensus. I observed this reluctance in two instances: developing a shared definition of the information problem (week one) and negotiating shared understanding of the IBL design rubric in the practice evaluation activity (week five). In the case of the information problem, the lack of negotiation may have been a function of too short of a period coupled with it being the first week of the course. During this week, students were occupied with introducing themselves to the class, welcoming each other, and participating in the first reading discussion. They may have read through the problem scenario carefully but did not find any need for further "definition" with each other, assuming that it was all there and already clearly defined. Although the instructions did dictate that they needed to develop a shared definition (indeed it is a step in the Big6™ process), they did not do it. Instead, each student interpreted the problem, identified their own individual research questions, and posted the title of the book they had selected to review. Although I was troubled by this, I decided not to intervene at that point, knowing that I would have a chance to address it when I debriefed the problem in week four.

The other instance was the practice evaluation activity. Students were provided three example inquiry-based learning designs, asked to "score" these designs using the rubric, and post their individual scores for each design by Thursday (which happened to be Thanksgiving). Although only half the class had posted scores, I compiled results of all evaluations into a spreadsheet and posted them on Friday. Students were then to discuss areas of considerable disagreement, which I had highlighted in the compiled results. I updated the results document after the remaining students posted their evaluations. However, even though the areas or criteria that yielded the most disagreement were already highlighted for them, students seemed very reluctant to further discuss why they assigned the scores they had assigned. One student had identified two criteria and terminology on the rubric that he felt a bit uncertain about, but others in the class did not respond to his post with their interpretations of those terms or further discuss why they assigned scores as they did. Late afternoon on Sunday (nearing the end of the activity) and in response to an additional prompt from me, a student explained she had assigned scores based on her interpretation of the words and phrases on the rubric. It was then that I realized that students did not seem to know that discussing those very words and phrases was what they should have been doing.

Although what students needed to discuss was hard scaffolded into the instructions for the activity, only one student seemed to understand the task at hand. Clearly many students in this class required some additional scaffolding for how to socially negotiate the varying interpretations represented by the scores they assigned using the rubric. Yet, what's mystifying about this case is that one student did identify criteria and terminology for discussion early on, but others did not respond to his post. This coupled with the lack of discussion on the information problem scenario suggests that there may be a deeper issue than unclear instructions alone. Indeed, I did assume that students, the majority of whom are teachers or administrators in K-12 schools, had some experience building consensus and reconciling different interpretations. That may have been an unfair assumption. Regardless of the level of experience, at a minimum, students did not seem to recognize that both of these activities required developing a shared understanding and/or didn't know how to go about developing it. In a course designed on principles of student-centered learning, it is not enough to provide opportunities for socially negotiating meaning, one also has to design adequate scaffolds

to support that process. Although I had developed scaffolds for solving ill-structured problems, I found in teaching the course that I needed to develop scaffolds for consensus-building as well.

Selecting The Right Tools

In addition to developing scaffolds for consensus building, I may have to use tools other than asynchronous discussion boards for these two activities. It is likely that the reluctance I observed was confounded by using a readily available tool instead of the right tool for the task.

Although I still hesitate to do so, it may be worthwhile to conduct one synchronous chat or videoconference during the first week of class to launch the PBL activity and develop questions that then drive selection of books to review. Alternately, I could send students to another tool outside of the CMS that has better affordances for brainstorming than a threaded discussion. A word wall or whiteboard would better support them in this process and may provide more authenticity to the scenario. They were asked to roleplay as something other than a student in a class, yet the "stage" for this roleplaying was in our class space. A meeting space outside of the CMS could make this simulated experience feel more genuine. Moreover, I was unable to use a pseudonym for my role in the scenario, given that I cannot change my identity in the CMS (I only have login credentials for myself). However, I could do so in Padlet, and I think students would be less likely to raise course or assignment related questions in their brainstorming and more likely to generate valid problem-related questions when someone other than their instructor is leading their efforts, even though they are aware that the instructor is playing the role. In other words, it would be easier for students to stay in character if I seemed more like a character and less like their instructor. I stayed true to my role, but my real name was attached to each of my posts making it hard to distinguish instructor-me from the role I was playing.

I also need to find a tool other than a threaded discussion for the practice evaluation. I could present the table of scores with highlighted areas of disagreement in a tool that allows them to share their thinking through other media (audio or video). VoiceThread, Flipgrid, or Nearpod are all possible candidates for this. However, I think that even posting the evaluation results as a Google sheet, so students can attach comments to individual scores or criteria would likely improve their engagement in the activity immensely. I'll likely ask students whether they have a preference or try both approaches and see which seems to work better.

Developing Dispositions For Open-Mindedness

The week six discussion on Hare's glossary was a high point in the class. Students were asked to select 3-5 terms from the glossary to comment on, and students' posts expressed many of the dispositions I aimed to foster in some form or another: [comfort with] uncertainty, humility, wonder, surprise. They came to realize that uncertainty is what leads to questions; certainty does not. They acknowledged that they were not all experts on every facet of what they teach, and that they did not need to be. Creating opportunities to wonder rather than be sure were valuable endeavors.

What was considerably less successful in this discussion was that I did not get much insight into which of the design strategies I implemented had the impact I intended. The prompt asked them to identify what components of the course contributed to their thinking about the terms they chose to reflect on. I listed them parenthetically in the prompt (articles, weekly list of quotes, book review project, reading discussions, design project, example designs, design project rubric, humor offerings, the intended "atmosphere" for the course). Student responses largely just listed them too and varied from student to student. Most simply indicated the course component without elaboration on how it affected them. One student indicated that the entire course supported developing wonder, writing "the course as a whole got me to wondering about how the professor chose to structure it rather than the mundane, typical college class where you submit an assignment and hope for the best. The course, in and of itself, was structured to make us wonder and seek answers; a pedagogical approach that we are aiming to use with our very own students." Although I want to know more about which approaches had the most effect, it seems that different students favored different aspects of the course, and a few attributed their understandings to the totality of course elements rather than individual elements of the design. Nevertheless, I would like to modify the prompt a bit to see if I can get a clearer understanding of how various course elements influenced students. At a minimum, I'd like to know if any design element worked counter to supporting open-minded inquiry.

Changes In Students' Thinking

Compiling results of the TBTUS for students took some time, which would have been well spent if students found value in it. However, no one commented on changes in their scores from the beginning of the course to the end, or how their scores compared to the rest of the class. This is likely because the prompt for the final discussion stated they were not required to do so. They were obligated to respond to the "I used to think . . . Now I think . . ." routine. I use this thinking routine as the final reflection in almost every course I teach, so students are used to it from other courses. But they also seem to really enjoy it. The changes in their thinking that they express in their responses, and the comments they make to their classmates are usually the most powerful expressions of learning that students make each semester. I offer a couple of example posts and peer replies in Table 3 on the next page.

STUDENT RESPONSE TO PROMPT	REPLIES FROM CLASSMATES
1. I used to think that I had a handle on what PBL was: project-based learning. I thought that I had a pretty good foundation and exposure to it, even having the audacity to insist to other teachers that that was what I was doing for higher-than-average students during intervention time while I worked with academically lower students. I never thought it was to babysit, but I thought that it was rigorous to try to solve a 'difficult problem'. Now I think that I didn't have an true understanding at all. In reflection, I never actually had a PD or any kind of development, so where did I get this false sense of knowledge? I do feel like I have a stronger foundation realizing that inquiry is not just questions or just solving a problem. Having taken new trainings as an instructional coach this year, I now see the difference between teaching a PBL and coaching a PBL - which I feel is a VERY big difference. I think that I still need more understanding, as it is a very complicated and abstract concept, but I am much better off than where I was before.	• These are strong, powerful reflections on yourself. Not everyone can do that, and I applaud you for your bravery and willingness to improve. I think for myself the biggest difference was adjusting the idea from just giving students a project, to giving them a problem to solve creatively. You know? • I agree that teaching PBL and training for PBL are two totally different things. I feel very similar to you in the sense that I didn't really have a true understanding of what it was until this class. I wish that school districts and college programs had a better understanding of what it was to teach and implement PBL. It is definitely the best for our students! Great post! • I never really thought of project-based as babysitting, but now looking back I think it as more of babysitting. The students really enjoy the projects, but they really are basically just doing what they are told. • I am glad you have been able to take additional training to help gain a better understanding of PBL. Hopefully, this helps your co-workers and ultimately it will be an asset to your students.
2. I used to think that PBLs were overwhelming and just too difficult for me to do with my students and that it was something we were not going to have time for— (I do try and not make excuses for them, but they really are a special population of students. Push them, yes I do, but this commitment a bit much) The time commitment to a PBL was too much and then the idea of even adequately meeting requirements defined by the Galileo rubric was just not gonna happen. My students would need too much guidance and the task would need to be very defined and guided. I thought there was a PBL formula and that we would be able to fill in the missing parts—similar to a story map to fill in. Now I believe that PBLs are possible for all students. The time, rigor, and critical thinking is worth it. The development of questions is important and can drive the PBL. Allowing the students to wonder can lead a PBL in a different totally different direction than the teacher thought it would. I know that when implementing a PBL, I must be open minded to it going a different direction than I had planned. Coaching through the PBL is a must and a teacher has to be prepared with scaffolds to help students along the way when necessary. I don't think I should be afraid of finding "experts" to be a part of my lessons. I know that I am going to be brave and try one soon. I will need to be ok with making mistakes and as my dad, the retired teacher would, "monitor and adjust as needed." I will use it as a learning experience with the students and improve from there. Collaborators are a must with PBL and I will find me a few to be my PBL tribe at school. PBLs are worth it.	• That is the spirit! I love your commitment to being brave even after admitting how incredibly uncomfortable you are with this idea. Gosh, we all mess up all the time though, its part of our profession. Just yesterday, I had planned out this cool, creative STEM lesson for my class and was so excited- absolute disaster. I was so deflated going home. But we have to remember these failures are learning experiences and teach us how to hone our skills and be better. Best of luck! And don't be afraid to fail! We are all failing out here :-) • Girl, I still think that PBLs can be totally overwhelming, especially if they are being implemented by a solo teacher. There's a lot of prep work and planning that go into PBLs, and as always, two heads are better than one! I love the collaboration that results from PBL and think that it benefits not only students, but coworkers and colleagues as well. Great post, and I enjoyed learning alongside you during this course! • Feeling uncertain but carrying on because we know what is best for our students represents why I love teachers so much. There are always huge changes that come our way but we are always willing to give it a try. I appreciate your honesty in this post and have had similar feelings. I think that most of my teachers feel similar and view it as "one more thing." It is going to take a lot of training on my part for my teacher's to see the value added from using PBL. Great post!
3. For me, I had a lot of background in Project Based Learning. It was a part of the core of classes the district I worked in offered for the gifted and talented teachers. I knew quite a bit, or so I thought. Taking this class I learned that Problem Based Learning existed. I had never heard this term before taking this class. While I feel there are some similarities, they both have distinct differences. As far as my thinking, I didn't see much change in the way that I thought from beginning to end. I did however see a change in the way that I design and create for Problem Based vs Project Based. This course made me think and made me struggle at times to decide how something should be. It made me stretch my thinking and it challenged me to think more outside of the box. It also made me realize even more how important inquiry really is. And it made me realize how many assumptions we make that are so inaccurate! I fully believe PBL will help our students to become the best thinkers and bring creativity back to the classroom.	• Yes! There are so many incorrect assumptions out there when it comes to PBL, but I'm so glad to have a variety of books and resources to share with my colleagues! • I love the separation you make with problem based learning and project based learning because at first glance most people think its just a different wording of the same thing. But problem based learning is a whole new ballgame; a new dimension of complexity to lay down on top of that PBL! Best of luck to you and your future problem based learning lessons! • Inquiry is so important and our students will value from these methods in the classroom. I too was only familiar with project based learning. Learning about other methods has gotten me excited for my students and the possibilities we can discover in the classroom. Great post!

TABLE 3. Responses to "I used to think . . . Now I think . . ."

Before parsing some of the insights expressed in these posts, I would like to assert that I did not cherry pick these posts and replies. I started at the top of the forum with the first two examples representing the last two posts that received comments (the forum displays most recent activity). I did skip the third post solely because of its similarity to response 2—expressing the idea that "I used to think PBL was overwhelming and difficult"—and included the fourth thread instead.

These student responses to the prompt show several key changes in thinking:

- The prior knowledge they had of PBL was knowledge of project- rather than problem-based learning. The course clarified their understanding of both methods.
- The misconception that PBL could only be implemented with advanced learners and the assumption that PBL would leave developing learners floundering without guidance were dispelled. Students learned that PBL environments can and must be designed for students' stages of development, including appropriate scaffolds for the problem-solving process. As expressed in example 1, "I have a stronger foundation realizing that inquiry is not just questions or just solving a problem."
- Giving students answers to questions and telling them what and how to do something are not the ways to "teach" critical and creative thinking. "Allowing the students to wonder" (example 2) and recognizing "how important inquiry really is" (example 3) are better ways to support development of these abilities.

In addition to these shifts in thinking, I was happy to see students continue to express so many of the dispositions for open-mindedness. As I detailed earlier, these dispositions include (but are not limited to) the following:

- flexible thinking: a willingness to change one's mind in light of new evidence after critically examining its merits.
- a degree of comfort with uncertainty: not an absence of conviction, but the humility that what's right or wrong or certain in one situation may not be in another
- risk-taking and perseverance: a willingness to make mistakes and learn from them rather than giving up too soon.

The student who posted example 1 expresses some flexible thinking when she questions, "where did I get this false sense of knowledge?" and her classmates applaud her "strong, powerful reflections" as well as her "bravery and willingness to improve." The student who posted example 2 is developing a comfort with uncertainty, writing "I know that I am going to be brave and try one soon. I will need to be ok with making mistakes." One of the classmates who responded seems willing to take risks, describing one of her own failures the prior day. "Just yesterday, I had planned out this cool, creative STEM lesson for my class and was so excited- absolute disaster. I was so deflated going home. But we have to remember these failures are learning experiences and teach us how to hone our skills and be better." Although I am not certain which (if any) of the strategies I deployed to support development of these dispositions were most successful, I am pleased to see some evidence of success.

CONCLUSION & FUTURE CHANGES

Overall, this design case showed me that it was possible for me to develop online courses using principles of student-centered learning design. Although initial implementation did not go precisely as expected, I learned a great deal about designing online, student-centered learning environments. Moreover, I found that the primary issues with the course were not due to either the student-centered approach or the online delivery mode.

Prior to designing and facilitating this course, I strongly believed that classes with fewer students resulted in better learning experiences for participants. This class challenged that belief. When a class is designed on principles of SCLE design, having enough students to provide an array of differing perspectives is critical. In this case, the smaller class size combined with the timeliness of student contributions adversely affected the number of perspectives presented. Addressing this particular issue requires an administrative move rather than a design change, namely not holding the class unless twelve to fifteen students enroll. Redesigning the class so that it doesn't rely on student interaction with each other to negotiate meaning making would not be in keeping with the foundational principles underlying the design or align with the inquiry-based methods that are the subject of the course.

While the course seemed to provide ample scaffolding for critical thinking and problem-solving, I did not provide enough scaffolding for students to develop a shared understanding in two activities in the course. Further exploring the source of students' reluctance to negotiate consensus, identifying ways to scaffold that process, and selecting more appropriate technology tools are opportunities for further improvement of the design that could address this issue. For example, taking the students outside of the CMS into a Padlet word wall for the information problem scenario that scaffolded book selection could address the surface level discussion that happened there.

To improve the practice evaluation activity, providing example responses that make use of the murkier terms in the Galileo rubric could address students' failure to do so. However, a threaded discussion didn't seem to be the best tool for that job either. Instead of downloading a spreadsheet with the results, interpreting them, and making a post in a threaded discussion, it might be more effective to post the results in a Google Sheet and have students embed

comments directly into the sheet on cells containing scores with significant disagreement.

Finally, modifications to key reflection prompts could provide clearer insight into what aspects of the course design had the most impact on students' cognitive and affective development. However, the priority in the final week of class is for students to provide peer feedback on the design projects and reflect on their learning in the course. My interest in what aspects of the design they attribute their learning to is secondary to those activities. Any prompt for reflection on their learning in the course will continue to emphasize these priorities.

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