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Chapter 3
Scaffolding Problem-Solving and Instructional Design Processes:
Engaging Students in Reflection-in-Action and External Representations in Three Online Courses

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ABSTRACT

Instructional design is an applied field of study that involves considerations for complex problem solving and authentic learning. Instructional guidance and scaffolding is particularly critical in facilitating online instructional design students, thus helping them succeed. In this chapter, the authors share how they designed and facilitated three instructional activities in three courses to scaffold a student-centered learning environment online. Using a case study approach, the authors describe their design considerations and how the instructor made decisions to incorporate external representations as a unique instructional technique into the three courses. Through student self-reporting, the instructor's formative and summative evaluation, and the authors' close review of drafts, the design process resulted in final products that were refined and noticeably improved. The authors conclude the chapter by reiterating the importance of scaffolding the problem-solving process with external representations and provide recommendations for future researchers and practitioners.

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INTRODUCTION

While the earliest face of online learning, distance education, has existed for merely a few decades, the evolution of online learning has been growing exponentially in the higher education field. Driven by economic, social, and technological changes of the digital era, online learning has been rapidly taking the place of traditional face-to-face classroom learning and becoming one of the most promising practices in higher education (Rudestam & Schoenholtz-Read, 2010). As faculty members from an institution carrying 30 years of experience delivering higher education at a distance, the authors strive to improve instructional and pedagogical practices of online learning to help graduate students prepare for an ever-evolving, complex world. This chapter focuses on this overarching question: how can instructors provide an online learning environment where instructional design students engage in collaborative reflection and ideation, and enhance the design process when problem-solving?

The context of the study resides in an instructional design and technology (IDT) program where the majority of students are online students who work fulltime. Online courses are offered both synchronously and asynchronously. Almost all IDT students take their courses via video web conferencing delivery methods while these courses occur in real time on a specific day and time each or every other week. Students are able to engage and participate in class discussions and activities with all of their classmates at a distance. With a webcam and microphone, online learners can participate in real time during live online classes, seeing and hearing the instructor and all of their classmates. During the weeks where students do not meet synchronously, instructors design online, asynchronous activities so that students can participate in Blackboard, or other technology-supported platforms and applications. This format of blended learning provides unique opportunities to engage students in collaborative, reflective learning and problem-solving.

The authors designed instructional activities for three different IDT courses and focused on three aspects of collaborative problem-solving in an online learning environment. First, the authors provided students with ample opportunities to reflect-in-action when solving ill-structured problems. Reflection-in-action requires students to monitor and adjust their behaviors while engaged in the learning activity when it is happening (Schön, 1983). When students think on their feet, keep their wits about themselves and learn by doing, students can not only critically think by doing but can critically think about doing something while doing it. Second, the authors engaged students in practices and activities where students can seamlessly design and develop external representations. External representations, such as prototypes, sketches, models, and concept maps, are documentation and reflections on what is happening in the design; are made to communicate to the designer; and provide information, interpretation, and inspiration for ideas (Huybrechts,

Schoffelen, Schepers, & Braspenning, 2012; Welch, Barlex, & Lim, 2000). Third, the authors used scaffolding techniques via a learner-centered approach to highlight and reinforce collaborative learning by having students provide peer feedback. Peer feedback allows students to engage in a dialogue with their peers by exchanging and communicating comments and ideas intended to improve their own work (Hattie & Timperley, 2007). Scaffolding in this study is a crucial element as it provides continuous guidance to learners leading them on the learning path from the start toward mastery of a task (Belland, 2014). Without scaffolding, students would have not been able to produce design works of such high quality.

Despite the flexibility, accessibility, and affordability often bolstered in online instruction, learners in online learning environments may lack frequent meaningful interactions with the learning content, their peers, and the instructor (Croxton, 2014). Using three case studies, this chapter presents how the authors as designers and instructors created, for three online instructional design courses, a student-centered, online learning environment that engaged graduate students in external representations and the reflection-in-action process. Students had ample opportunities to interact with designs, as well as peers and the instructor.

BACKGROUND

Designers are reflective participants in a design process. Through reflection-in-action, designers participate in a reflective conversation with design situations as designers examine a design's strengths and weaknesses (Schön, 1983, 1988). The idea behind reflection-in-action is that unique and uncertain situations are understood through attempts to change them, and changed through attempts to understand them. When designers keep their wits about them and think on their feet, designers think about doing something while doing it (Schön, 1983).

When designers confront ill-structured problems that are uncertain and unique, a design situation becomes episodic as designers step back and reflect on how a problem has been framed (Cross, 2011; Schön, 1983). Within a frame, designers reframe the problem, redefine constraints, and welcome the opportunity to discover innovative solutions (Brown, 2009; Dorst, 2012). Designers use external representations to document and reflect on what is happening in a design frame. An external representation talks to the designer; providing information, interpretation, and inspiration for ideas (Huybrechts et al., 2012; Welch et al., 2000).

External representations can be spreadsheets, sketches, models, prototypes, outlines, concept maps, tables, wireframes, etc. Whatever the form of the external representation, designers give themselves something to react to and they make it rich (Baaki, Tracey, & Hutchinson, 2016). Rich external representations are set in

authentic situations that are real-life, informative, and engaging so that the external representations allow for reflection-in-action (Huybrechts et al., 2012). Real-life situations indicate that the external representation makes clear the design context and constraints while informative and engaging mean that the external representation apprises the designer and is expressed openly enough to allow for interpretation (Baaki et al., 2016). External representations prompt evaluation practice highlighting interpretation and sparking an enhancement design process. Enhancement is not iteration where earlier design components are revised. Enhancement is adding onto the design work that was already done (Tessmer & Wedman, 1990).

External representations and reflection-in-action support one another. When external representations constantly talk back to a designer (Cross, 2011; Schön, 1983), a designer interacts with external representations and appreciates the context under which the external representations are made, reframes the design situation, and then openly interprets the design frame (Baaki et al., 2016; Schön, 1983, 1988). Reframing and openly interpreting the design situation ends in new discoveries that can be represented externally. By engaging students in taking stock in external representations, the authors provided a learning environment where peer-to-peer and instructor-student scaffolding could flourish.

The concept of scaffolding can be traced back to the 1970s when Jerome Bruner and his colleagues studied children's language acquisition and early childhood cognitive development. Scaffolding was originally referred to as an adult's effort and assistance to children to comprehend knowledge, problem solve, and master a task (Bruner, 1974; Ratner & Bruner, 1978; Wood, Bruner, & Ross, 1976). In this sense, the adult (expert) who has acquired a higher level of knowledge and expertise provides guidance to children (novice learners). Scaffolding was later extended to embrace various types of guidance, techniques and assistance provided by peer learners and computer-based learning systems and environments (Cohen, Manion, & Morrison, 2004; Foley, 1993; Van Merriënboer & Kirschner, 2017).

Scaffolding is closely tied to Vygotsky's Zone of Proximal Development (ZPD). ZPD as defined by Vygotsky (1978) is the distance between what a learner can achieve independently and unassisted and the level of potential cognitive development with expert or peer guidance. The type of guidance needed to achieve or perform at a higher level in Vygotsky's ZPD theory echoes what is understood as scaffolding. A learner would not be able to understand or achieve on their own without scaffolds such as tools, techniques, and strategies. Essentially, scaffolding is a vital component provided externally to help a learner on the learning path toward the maturation of understanding or mastery of a task. Analogous to the literal meaning of a scaffold, scaffolding is a temporary support system that "allows students to meaningfully participate in and gain skill at tasks that they could not complete unassisted"

(Belland, 2014, p.2). Scaffolding continues until the tasks can be completed by students without support.

Scaffolded instruction is "the systematic sequencing of prompted content, materials, tasks, and teacher and peer support to optimize learning" (Dickson, Chard, & Simmons, 1993). Scaffolding as an instructional strategy is at its heart student-centered in that it is geared towards a tailored and differentiated instructional model aiming to meet students' disparate needs in different learning stages (Resier, 2004; Van Merriënboer & Kirschner, 2017). When encountering new and difficult tasks or environments, students are provided with more assistance. As students' learning progresses, instructors reduce assistance or support and transfer the learning responsibility from the instructor to the students. The instructor will continue to monitor students' learning processes, reduce the amount of guidance and assistance, and eventually remove the scaffolding until students can demonstrate that they can perform the task successfully without assistance (Lipscomb, Swanson, & West, 2004).

Along with the instructor, peer learners who have reached a higher state of cognitive development and knowledge construction can scaffold an individual learner at the time of need (Ge & Land, 2003; Nicol & Boyle, 2003). Most recently, a wide variety of computer-based learning environments, such as self-contained software systems (e.g. Linn, Clark, & Slotta, 2003; Sandoval & Reiser, 2004) and web-based online discussion forums (e.g. Choi, Land, & Turgeon, 2005; Jeong & Joung, 2007; Ng, Cheung, & Hew, 2010), appear to hold tremendous potential in supporting learners at different levels and creating a more personalized learning experience.

There is a multitude of specific scaffolding techniques and guidelines existing in the literature (Belland, 2014). Hogan and Pressley (1997) synthesized prior literature, identifying a conceptual framework containing eight essential components and guidelines for teachers intending to use scaffolding. The eight components are: a) pre-engage with the student and the curriculum, b) establish a shared goal with students, c) be sensitive to student needs and understandings, d) provide tailored assistance, e) help students remain focused on reaching the learning goal, f) provide continuous and timely feedback, g) monitor frustration and risk control, and h) assist internalization and learning transfer. Kali and Linn (2008) proposed four meta-design guidelines for scaffolding science inquiry, including: a) make science accessible, b) make thinking visible, c) enable students to learn from each other, and d) promote self-directed learning. Pea (2004) postulated a four-component scaffold design principle, which is comprised of: a) predict a sufficient support level for enabling a student to perform a specific task, b) distinguish between learners at different developmental levels, c) account for combining various types of scaffolds, and d) consider the role of human scaffolding. Regardless of whether a technique or strategy is labeled as a scaffold, researchers argue that it needs to take into account students'

performance characteristics, the nature of the task and activity, as well as ensuring the transfer of responsibility from the scaffolder to the scaffoldee (Belland, 2014; Pea, 2004; van den Pol, Volman, & Beishuizen, 2010). The types of scaffolding tools or techniques operated either by human instructors, peer learners, or computer-based systems ought to be able to monitor student performance and interaction and respond to students' needs in a timely manner. Although the authors in the current study did not follow a specific scaffolding model, the authors did incorporate the scaffolding elements described above.

THE PURPOSE

Although technologies enable learners to collapse geographical and temporal barriers and allow for flexibility and easy access to learning materials from anywhere and usually at any time (Driscoll, Jicha, Hunt, Tichavsky, & Thompson, 2012), it does not automatically grant students a greater command over autonomous learning, nor does it free designers and instructors from providing intentional scaffolding and instructional support. Instructional guidance and scaffolding is particularly critical in facilitating online students thus helping them succeed.

Specifically, in the context of an instructional design course, prior research suggests that traditional means of a semester-long course in higher education failed to mirror the recursive design process that takes place in the real world of instructional design, resulting in underprepared instructional designers entering the instructional design workplace (Karagiorgi & Symeou, 2005). In the real world, instructional design projects are complex, imperative, and practical problems requiring solutions within multiple constraints (Gordon & Zemke, 2000). In an educational design course, Huybrechts et al. (2012) witnessed inexperience design students jumping to a design solution as quickly as possible. To check design students' inclination to jump to solutions, Huybrechts et al. probed external representations to spark a reflective design process. With proper scaffolding using external representations, students interact with and evaluate design drafts and discover meaning in what is designed.

In this chapter, the authors share how they designed and facilitated three instructional activities in three courses to scaffold a student-centered learning environment online. Using a case study approach, the authors describe their design considerations and how the instructor (second author) made decisions to incorporate external representations as a unique instructional technique into the three courses. Design considerations entail a discussion of the interplay between all technologies that the authors chose to adopt to meet the learning goals including both a central online diagramming and mapping tool and other complementary Blackboard and web conferencing tools. In the following section the authors present the three case

studies in great detail, specifying how they scaffolded students' problem-solving and design process to meet the learning goals. In all three activities, over the length of the design assignment, students had the opportunity to share their rich external representations with the instructor and fellow students who then reacted to them. Using data collected from students through an analysis of learning artifacts (design sketches, Blackboard reflective discussions posts, and video-recorded synchronous class discussions) and summative online surveys, the authors also discuss students' learning perceptions, learning outcomes, as well as reflections from the instructor. The authors conclude the chapter by reiterating the importance of scaffolding the problem-solving process with external representations and provide recommendations for future researchers and practitioners.

METHODS

The study participants were graduate students enrolled in three different courses. Most graduate students were distance students working full-time in instructional design. Though student enrollment varied by each course, a total of 24 participants were involved in the study. Some students were enrolled in more than one class but were only treated as one participant in this study. In this chapter, we have changed the names of students. Accounting for space considerations, from our study, we have included student reflections and design projects that best represent the importance of scaffolding the problem-solving process with external representations.

Data Collection

For all three courses, as part of students' design project assignments, the authors gathered teams' draft #1 external representations which were presented in a WebEx class, drafts #2 which were posted on Blackboard, and final design presentations. After the final design presentations, teams submitted the presentations through Blackboard and the instructor downloaded the presentations. The instructor organized and archived teams' drafts and final presentations in file folders by class, project, draft, and final presentation.

Following the final design presentations, students participated in an online survey where students provided feedback and reflected on the learning process. In the first section of the survey, students specifically reflected on Cacoo as the chosen tool for students to produce external representations. We discuss our choice of Cacoo below. Students described their overall perception of using Cacoo, as well as Cacoo's performance in usability, ease of use, and usefulness. In the second section students reflected on their perceived learning and the design process with Cacoo-supported

external representations, including the peer review process as part of their design project. Finally, the authors included three open-ended questions to specifically solicit students' feedback regarding: (a) how the external representations accounted for design constraints and context, (b) whether external representations were expressed openly enough to allow for interpretation, and (c) how creating Cacoo drafts and reflecting on the drafts helped students move from discovery to design decisions.

Students reacted to teams' first drafts in a WebEx class then teams shared their second drafts on Blackboard. The instructor posted prompts on Blackboard to scaffold the design and reflection-in-action process. The instructor downloaded students' prompt reflections and then organized the prompt reflections in file folders by class, project, and student reflections.

Data Analysis

To share how the authors designed and facilitated three instructional activities in three courses to scaffold a student-centered learning environment online, the authors first used descriptive statistical analysis to analyze quantitative items from the survey data. Responses to surveys from the three instructional design courses were combined and aggregated. The authors also triangulated the survey results with students' responses to the open-ended questions that asked them to provide further explanations to their ratings. For the survey's three open-ended questions and the Blackboard prompt reflections, the authors applied a constant comparison method to analyze information units pertinent to scaffolding in a student-centered online learning environment. To establish trustworthiness, the authors applied Lincoln and Guba's (1985) four criteria: (a) credibility, (b) transferability, (c) dependability, and (d) confirmability.

THREE CASE STUDIES

Context

The IDT program meets the needs of professionals interested or involved in the design, development, and delivery of instruction by providing graduate students with a strong foundation in instructional design, cognitive theory, and research. Our students' background stem from a variety of venues, including preK-12, higher education, military, healthcare, and business. The program is housed within the College of Education of the university and in the department of STEM Education and Professional Studies. Lodged in a graduate instructional design and technology (IDT) program at a large public university in the southeastern United States, the

instructor taught three courses: (a) Foundations of Distance Education, (b) Non-instructional Interventions, and (c) Principles of Human Performance Technology. Although student enrollment varied in each course, 22 students were enrolled in the three courses with some students enrolled in more than one class. All three classes were distance learning classes that used both Blackboard and WebEx. Blackboard is a learning management system that the university chooses to utilize institution-wide and WebEx is a videoconferencing tool that the university uses for synchronous live class meetings. WebEx classes took place at the university's teletechnet building where local students could physically attend class with the instructor. Within the WebEx environment, distance students engaged in live class discussions and activities with all of their classmates regardless of location. In selected weeks, students joined asynchronously online in Blackboard discussion forums with instructor facilitation and scaffolding. Cacoo was chosen as the tool for students to produce rich external representations.

Choosing Cacoo

To spur students' creation of rich external representations, the authors chose Cacoo as the web-based tool for creating maps, diagrams and flowcharts online. Cacoo offers a free plan for educators: https://cacoo.com/education. Current conceptual mapping tool literature illustrates that students are able to use conceptual mapping tools to facilitate and visualize a reflective and critical thinking process that leads to external representations such as prototypes, sketches, flowcharts, concept maps, and graphs (Faste & Lin, 2012; Harris & Zha, 2013; Lin & Faste, 2011). The authors were determined to discover a tool that would provide students opportunities, at any time, to seamlessly react to design drafts. Being an agile, cloud-based program, Cacoo allowed students to instantly save multiple versions of external representations as discrete diagrams. Cacoo also contained various collaboration features like chatting and sharing that allowed a team of two students to communicate and distribute work with one another at any point in time during the enhancement design process. The authors considered the collaboration features critical to reflection-in-action as well as reacting to rich external representations.

During a Cacoo introduction session, the authors explained to students the Cacoo choice by making it clear that every concept mapping tool has its strengths and constraints. Students used a free Cacoo version, which limited features like exporting choices and number of saved drafts. The goal was to have students deal with Cacoo's constraints given the project time frame. The authors encouraged students to maintain an open mind if Cacoo lacked some required features to produce students' specific external representations.

Three Design Projects

The instructor promoted each design project similarly. The instructor introduced Cacoo and the specific design considerations. He then explained that teams would produce two design drafts and then conclude with a final design presentation. The authors used the Distance Education Time Machine design project (Table 1) as a pilot study (Baaki & Luo, 2016). Reacting to feedback from the pilot study, for the Non-Instructional Intervention Plan (Table 2) and Detroit Basket Works Intervention (Table 3) design projects, within the first three weeks of the semester, the instructor added a pre-design activity that allowed time for students to practice using Cacoo before they started the actual design projects

For each design project, for four or five weeks, teams made up of two students engaged one another, the instructor, and other teams with rich external representations. For each design project, the instructor established draft milestones where teams shared their rich external representations with the instructor and other teams who then reacted to the drafts. Students reacted to each other's first draft in a WebEx class then shared their second drafts on Blackboard. The instructor posted prompts on Blackboard to scaffold the design and reflection-in-action process and encourage peer feedback among students. At the end of each design project, in a WebEx class, each team presented its final design and responded to questions and comments. The instructor completed a graded summative evaluation of each final design and presentation.

External representations were important to the scaffolding process. As an experienced instructional design practitioner, the instructor lamented instructional designers' tendencies to not share drafts. The instructor's experience was that instructional designers often only share one draft with a client prior to the final design. The instructor wanted to create a scaffolding environment where multiple drafts were produced. External representations helped the instructor scaffold teams as he was able to specifically guide teams on what the team produced. For example, taking stock in a draft, the instructor could see if a team included the outlined design considerations of instructional design alignment and the reintegration of the teaching act. The instructor then could provide scaffolding on the design considerations to keep the design process moving. In each course, teams were designing to specific design elements and considerations.

Maybe more importantly, external representations assisted peer reviewers. Knowing that students were inexperienced designers and believing that peer feedback was important to the design processes, the instructor used design drafts as the anchor to peer feedback. Peers could not provide feedback to another team unless the team produced a draft. The rally call was give us something to react to. The instructor constantly reminded students to take stock in teams' drafts based on

the specific design elements and considerations. Some teams grasped the design elements and considerations quicker than other teams and then shared how they were interpreting the design elements and considerations. It was a dynamic process, through reflection-in-action, teams were experiencing and understanding how the design elements and considerations impacted the design process and then were able to share those experiences and knowledge with other teams. Although students may have been inexperienced designers, deeply engaged in their design process, teams became experts with their specific design and therefore were able to provide valuable feedback to other teams.

The following is a description of each design project. For each case, the authors discuss the learning goals, detail the scaffolding process, describe representative team external representations, provide representative team feedback, and share instructor reflections.

Design Project 1: Distance Education Time Machine

The Foundations of Distance Education course included masters and doctoral students. The Distance Education Time Machine design project was the major project in the course and represented 30% of master's students' final grade and 25% of doctoral students' final grade. The course had six course competencies and the design project directly aligned with three competencies: (a) analyze a distance-education system using criteria developed from existing knowledge base, (b) analyze the structure, interaction, and components of a distance education lesson, and (c) demonstrate a comprehension of the primary theories and concepts in distance education. Table 1 presents the specifics of the design project.

Table 1. The specifics of the Foundations of Distance Education course

Course (# of Students)	Design Project	Goal	Project Tasks and Milestones	Timeline	Required Elements of the Design
Foundations of Distance Education (8 students)	Distance education time machine	Set in a past or future time period, design a miner safety distance education program Time Periods 1890-1930 1930-1970 1970-2000 2000-2030	1. Introduce Cacoo and design considerations 2. Design first draft and present in WebEx class 3. Design second draft and post to Blackboard 4. Present final design in WebEx class	5 weeks	• Represent context and constraints of the time period • Account for miners' hopes, fears, and dreams, and what miners wants to accomplish • State changes in what miners are to do and/or think • Include effective activities and learning experiences • Include effective assessments

The Distance Education Time Machine design project lasted five weeks. Each team had to design a miner safety distance education program set in a specific time period. Each of the four teams had one of the following time periods: (a) 1890-1930, (b) 1930-1970, (c) 1970-2000, and (d) 2000-2030. Week-by-week, the following illustrates how teams responded to the instructor's scaffolding by taking stock in external representations.

Week 1

The authors presented a 20-minute introduction to Cacoo, focusing on Cacoo's general features:

- How to share and chat with a teammate.
- How to save work.
- How to use templates, draw diagrams, and color code items.
- How to export external representations.

The authors were mindful to provide a starting point without over-scaffolding. The authors invited teams to thoroughly explore Cacoo's strengths and weaknesses to determine how Cacoo could be best used to produce teams' rich external representations. The authors were careful not to prescribe how and what to do with Cacoo.

In order to scaffold and monitor reflection-in-action, the instructor encouraged students to keep in mind two fundamental design considerations as teams designed. First, address the three-pronged alignment between what miners are to do (outcomes), learning experiences that support what miners are to do, and effective assessments to measure the outcomes (Cennamo & Kalk, 2005). The instructor included the alignment design requirement in the assignment rubric and presented the alignment during the WebEx session as an instructor-produced Cacoo visual.

The second design consideration referred to Keegan's (1996) reintegration of the teaching act, which portrays a link between learning materials and learning (i.e. quantity of learning, quality of learning, and status of learning) in a distance education system. The point was to have teams reflect on how to create the moment when teaching and learning happens within the teams' distance education system. To present Cacoo's flexibility of layouts, shapes, and color-gradient feature, the instructor produced a Cacoo visual of the reintegration of the teaching act and shared it in the WebEx class.

The instructor concluded week 1 by describing the final design deliverable and each team's significant design constraint: the 30-40 year time period window. The instructor emphasized that in order to design distance education in the assigned time

period, teams would need to problem-solve what were the time period's distance education capabilities.

Week 2

In the week 2 WebEx class, each team shared a first draft. Heading into week 2, the instructor had explained that each team would provide the team, the instructor, and other teams an external representation(s) to react to and each team would make the external representation rich. The instructor explained that rich external representations are rooted in real-life situations that are both informative and engaging. He further stated that real-life situations mean that the external representation accounts for the design context and constraints while informative and engaging mean that the external representations provide information to the team and are expressed openly enough to allow for interpretation.

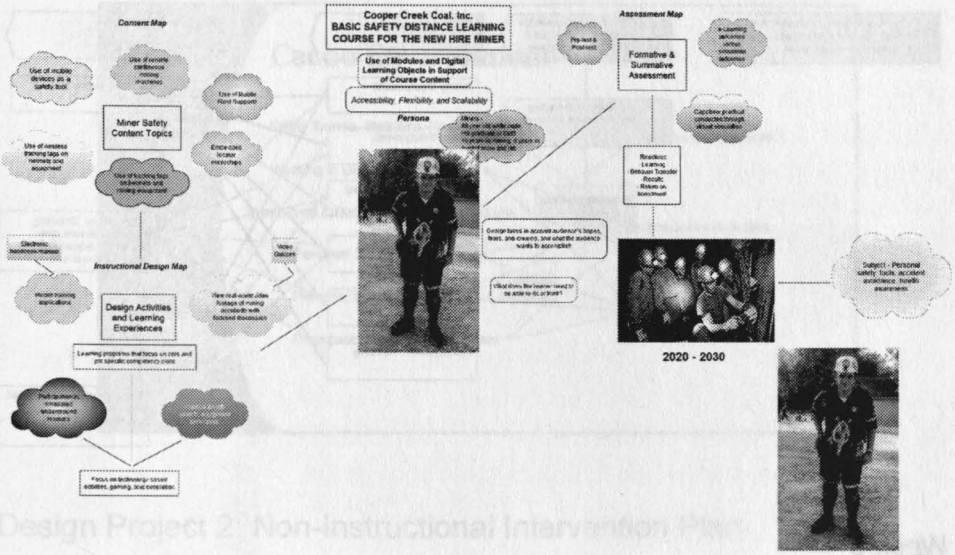
John, an occupational and technical studies doctoral student and Christine, an instructional design and technology master's student, designed miner safety training for the 2000-2030 time period. In sharing something to react to, John and Christine noted that they followed the assignment rubric to construct a miner persona and design a content and assessment map (Figure 1). The team engaged in reflection-in-action by working in real time using the Cacoo chat. Christine quipped that it was "weird" to watch John make changes in front of her eyes. John and Christine shared that they used a backward design approach. The team visualized the final training and then began to map out the important aspects that would lead them to the design deliverable.

The team's rich content and assessment map and miner persona were fixed in real-life and informative situations. As part of the design, the instructor supported students in placing themselves in the shoes of the miners. John and Christine constructed a 46-year-old miner who worked for Cooper Creek Coal, Inc., and had 16 years of mining experience. The team reduced its time period from 20 years to 10 years (2020-2030) and focused the safety training on personal safety, tools, accident avoidance, and health awareness.

Weeks 3 and 4

In week 4, teams engaged in an asynchronous, reflective Blackboard discussion activity. Teams posted their second draft on the Blackboard Community of Practice. In addition to collecting instructor and peer feedback on the team's external representation and giving feedback to other teams' drafts, team members responded to reflection prompts posted by the instructor. The instructor prompted teams to reflect on:

Figure 1.

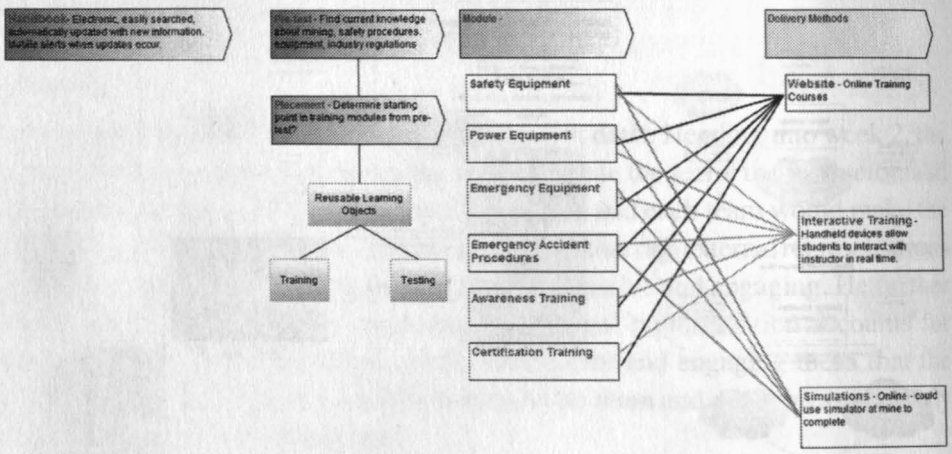


- Where is your draft at this point? How has it changed since the draft you shared in week 2?
- How has making Cacoo drafts and reflecting on the drafts help you move from discovery to design decisions or exploration to design commitment?
- How is your design addressing the reintegration of the teaching act (the link between learning materials and learning)?
- How are you addressing the alignment between changes in what miners do and/or think to effective assessments to ensure a change in what miners do and/or think to effective activities and learning experiences that support change in what miners are to do and/or think?

John and Christine's second draft visually presented the instructional elements of their miner safety training. Using multiple Cacoo pages, the team outlined six modules including e-learning and simulation goals and mapped each module to the delivery method (Figure 2).

The instructor was careful to have all feedback end three days prior to the final design due date. Scaffolding stopped and teams had the space to reflect and react to peer and instructor feedback, take stock in the second draft, and make final design decisions.

Figure 2.

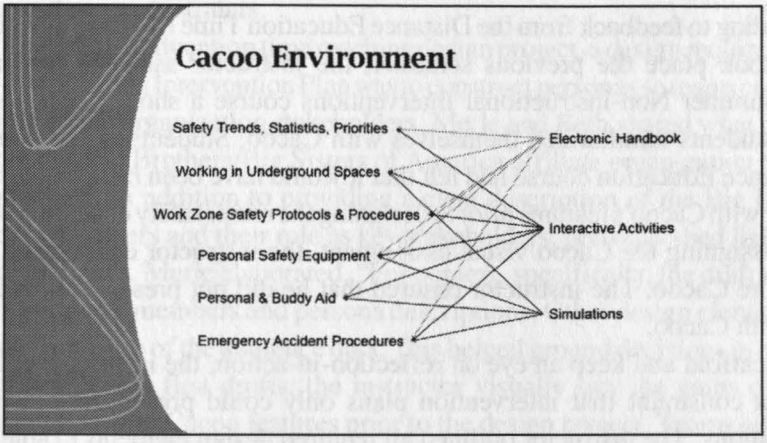


Week 5

Each team provided a 15-minute presentation of its final design. To prepare for the final design presentation, the instructor prompted teams to ensure that they addressed the reintegration of the teaching act and the alignment between changes in what miners do, effective assessments, and effective learning experiences. After each presentation, the instructor prompted students to comment and question the team's final design. Because Cacoo was a new technology for students and the final design was a graded assignment, the instructor allowed teams to present the final design in any format of their choosing. Even though all teams chose a PowerPoint format, all teams included Cacoo pages in their final design presentations. Final presentations showed how drafts evolved into final designs.

In the end, John and Christine designed to one year 2025. The final design was miner-centered, called for just in time training, and included simulations. The external representation from the second draft (Figure 2) matured into a compelling final design version (Figure 3). In commenting on the final instructional design, the instructor noted that even though all teams thought the 2000-2030 time period was the most interesting, the future time period may have been the most difficult. The other time periods had known constraints whereas John and Christine had to conjecture what may be the technological constraints. John and Christine noted that if they had not created constraints, they would have risked a design with a variety of futuristic technologies that had no continuity.

Figure 3.



Design Project 2: Non-Instructional Intervention Plan

The Non-instructional Interventions course included masters and doctoral students. The Non-instructional Intervention Plan was the major project in the course and represented 30% of master's students' final grade and 25% of doctoral students' final grade. The course had nine course competencies and the design project directly aligned with four competencies: (a) identify human performance interventions of a non-instructional nature, (b) identify criteria that should be a part of intervention design and implementation, (c) demonstrate an understanding of how the communication process and organizational communication interventions can impact employee behavior, and (d) discuss the broad scope of organizational design and development. Table 2 presents the specifics of the design project.

The Non-instructional Intervention Plan design project lasted for four weeks. Three teams designed a non-instructional intervention plan for an organization of their choosing. The instructor required that the organization be one which was familiar to at least one team member. One team implemented a knowledge-sharing tool for a shipbuilding facility. Another team created a guide to identify students with special needs and delays for a day school. The third team implemented an organization financial management toolkit for Big Brothers/ Big Sisters of America affiliates. The following demonstrates how teams reflected-in-action and produced rich external representations.

Week 1

Responding to feedback from the Distance Education Time Machine design project, which took place the previous semester, the instructor assigned students early in the summer Non-instructional Interventions course a short visual assignment where students familiarized themselves with Cacoo. Students in the Foundations of Distance Education course had felt that it would have been beneficial to become familiar with Cacoo's features prior to designing the miner safety education programs. When assigning the Cacoo visual assignment, the instructor encouraged students to explore Cacoo. The instructor ensured that he did not prescribe how and what to do with Cacoo.

To scaffold and keep an eye on reflection-in-action, the instructor emphasized a design constraint that intervention plans only could present non-instructional interventions. The instructor outlined all required design elements (Table 2) in the assignment rubric posted on the course Blackboard site.

Week 2

In the week 2 WebEx class, each team provided the instructor and other teams a first draft to react to. Unlike the distance education time machine design project where all teams were designing miner safety educational training, each team had a plan for a completely different organization. Teams' rich external representations

Table 2. The specifics of the non-instructional interventions course

Course (# of Students)	Design Project	Goal	Project Tasks and Milestones	Timeline	Required Elements of the Design
Non-instructional Interventions (6 students)	Non-instructional intervention plan	Design a non-instructional intervention plan for an organization that the team is familiar with	1. Introduce Cacoo and design considerations 2. Practice using Cacoo 3. Design first draft and present in WebEx class 4. Design second draft and post to Blackboard 5. Present final design in WebEx class	4 weeks	• Provide context and rationale for the non-instructional intervention • Include a persona construction which accounts for audiences' hopes, dreams, and fears, and what the audience wants to accomplish • Provide an appropriate analysis • State objectives of the non-instructional intervention • Include effective and efficient non-instructional strategies • Include effective and efficient assessments

were fixed in real-life situations that accounted for the organization's context and the ensuing design constraints.

Like the distance education time machine design project, a design requirement for the Non-instructional Intervention Plan was to construct personas so teams could walk in the shoes of the organization stakeholders. Merle and Beth shared what personas meant for their Big Brothers/Big Sisters of America affiliate organization financial management kit. In addition to providing a clear description of the Big Brothers/ Big Sisters volunteers and their role as key stakeholders, personas shed light on the context of affiliates. Merle elaborated, "For context, specifically, the draft included images of audience members and persona descriptions. Other design elements were built, visually, on top of the audience data. This helped ground decisions in context."

In reacting to the first drafts, the instructor visually saw the gains of having students practice with Cacoo features prior to the design project. Teams effectively used color gradients, varied the shapes of content area, imported images, and customized visual intervention plan timelines.

Week 3

In week 3, teams posted their second draft on the Blackboard Community of Practice. Team members received instructor and peer feedback on the team's external representation and provided feedback to other teams' drafts. The instructor prompted teams to reflect on:

- Where is your draft at this point? How has it changed since the draft you shared in week 2?
- How has making Cacoo drafts and reflecting on the drafts help you move from discovery to design decisions or exploration to design commitment?
- How is your design addressing the elements of a non-instructional intervention implementation plan?

Enhancing their rich first draft, Merle and Beth progressed toward new ideas based on the teams' interpretations and week 2 feedback from the instructor and other teams. Reflecting on the team's second draft posted on Blackboard, Beth commented, "Using external representations has helped us through the design process by allowing us to convert our ideas into visuals, move them around to explore various views of the external representations." Teams found the exercise of offering their designs and providing feedback on other teams' external representations productive. Merle noted, "It was an engaging experience, in the multiple drafts set-up a feedback loop where different teams could 'sample' and 'remix' useful ideas from other teams into their own designs." As with the distance education time machine design

process, the instructor stopped all scaffolding and feedback three days prior to the final design due date.

Week 4

Each team provided a 15-minute presentation of its final design. Knowing that each design was quite different, the instructor reiterated a required design element and directed teams to make certain that they provide context and rationale for the non-instructional intervention. After each presentation, the instructor and students asked questions and commented on final intervention plans. The instructor allowed teams to present the final design in any format. The instructor was pleased to see that all teams included Cacoo pages in their final design presentations.

Design Project 3: Detroit Basket Works Intervention Plan

The Principles of Human Performance Technology course included masters and doctoral students. The design project was the major project in the course and represented 25% of master's students' final grade and 21% of doctoral students' final grade. The course had nine course competencies and the design project directly aligned with four competencies: (a) analyze organizational goals and processes in order to identify performance gaps, (b) identify human performance interventions that are not instructional, (c) identify human performance interventions that are instructional, and (d) develop metrics for measuring and evaluating performance impact. Table 3 presents the specifics of the design project.

The Detroit Basket Works Intervention Plan design project lasted for five weeks. Five teams designed one intervention needed for Detroit Basket Works and designed an intervention implementation plan. Teams designing for the fictitious Detroit Basket Works received contextual information regarding past and present performance along with Detroit Basket Works future plans. Teams had the opportunity to have a face-to-face conversation with the Detroit Basket Works' CEO and to email two key stakeholders. As teams received more information as they progressed through the design, teams gained confidence that they were designing effective interventions. The following describes how the instructor's scaffolded the project and how teams took stock in their external representations.

Week 1

Similar to the summer Non-instructional Interventions course, the instructor assigned students early in the fall Principles of Human Performance Technology course a visual assignment where students familiarized themselves with Cacoo. As with the

Table 3. The specifics of the Principles of Human Performance Technology course

Course (# of Students)	Design Project	Goal	Project Tasks and Milestones	Timeline	Required Elements of the Design
Principles of Human Performance Technology (10 students)	Detroit Basket Works intervention implementation plan	Choose one intervention needed for Detroit Basket Works and design an intervention implementation plan	1. Introduce Cacoo and design considerations 2. Practice using Cacoo 3. Design first draft and present in WebEx class 4. Design second draft and post to Blackboard 5. Present final design in WebEx class	5 weeks	• Provide context and rationale for one intervention • Include a strategy for developing one intervention • Include a strategy for ensuring communication throughout the one intervention • Account for the Detroit Basket Works employees' hopes, fears, and dreams, and what the employees wants to accomplish • Include a plan for assessing political bases • Include an analysis of the intervention sequencing • Review intervention interference • Include a project plan for rollout • Include an evaluation plan

Non-instructional Interventions course, when assigning the Cacoo visual assignment, the instructor supported students in exploring all that Cacoo offered.

Once the teams were announced, the instructor emphasized that Detroit Basket Works needs multiple interventions. However, as a design constraint, the instructor explained that teams would choose one intervention and design an intervention implementation plan around that one intervention. The instructor laid out all required design elements (Table 3) in the assignment rubric posted on the course Blackboard site.

The Detroit Basket Works design project had multiple moving parts as teams received information throughout the design process. For weeks 2-5, the instructor presented the design project schedule as follows:

Week 2: In Blackboard, receive information regarding Detroit Basket Works.
Week 3: Present draft #1 in WebEx and interview R. E. Keen (CEO).
Week 4: Present draft #2 in Blackboard and follow-up via email with R. E. Keen and two other stakeholders.
Week 5: Present final intervention implementation plan in WebEx.

Week 2

In Blackboard the instructor prompted teams with three documents. First, teams reviewed the situation at Detroit Basket Works. In sum, Detroit Basket Works was witnessing a changing basket market where customers are looking for and willing to pay for unique vintage-looking baskets. Facing an emerging market, Detroit Basket Works has watched sales decline and received an increase in customer complaints. Customers say that the product is not what it used to be. Finally, Katie Gleason has replaced a well-loved manager and is not making friends very fast. To provide context to what Detroit Basket Works does, the two other documents were images of Detroit Basket Works vintage baskets.

The Detroit Basket Works situation document ended with prompts for teams' first drafts. With the information provided, teams were to create an external representation showcasing where the team is with its design. The instructor explained during the first part of the week 3 WebEx class each team will present its first draft and the instructor and fellow classmates will provide feedback. The instructor further stated that during the second part of the week 3 WebEx class, R. E. Keen, the Detroit Basket Works CEO, will be in class to answer any and all questions that will help teams with their intervention implementation plan.

Week 3

In the WebEx class, each team provided the instructor and other teams a first draft to react to. With the known situation at the week 3 milestone, although teams' rich external representations varied, all the first drafts were rooted in real-life situations that accounted for Detroit Basket Works context. One team began to design a quality assurance/quality control intervention while another team looked to increase employee motivation and ownership. Still, another team reflected on what was happening with Detroit Basket Works' packaging and shipping teams.

As teams received information regarding Detroit Basket Works, external representations helped designers organize and structure their thoughts. Shelly who along with her partner Joe focused on the packaging and shipping operations noted, "Sketching out the diagrams and flowcharts helped me put my ideas on the screen as I was thinking about it." For the team's design of an employee motivation and ownership intervention, Doug applauded Cacoo's sharing feature. He remarked, "The sharing feature was profound. We were able to talk during joint work and re-arrange the diagram on the fly. By doing so, we were visually communicating our vision of the diagram."

During the second half of the WebEx, the instructor role played Detroit Basket Works CEO R. E. Keen. For one hour, staying in character, the instructor answered team's questions about what was happening at Detroit Basket Works. The majority

of questions centered on Detroit Basket Works plan to satisfy the emerging vintage-looking basket market and Katie Gleason's, the new manager, role in the initiative. More than once, R. E. Keen stressed that teams would not have another opportunity to communicate with him face-to-face.

Week 4

Teams posted their second draft on the Blackboard Community of Practice. Team members took in instructor and peer feedback on the team's external representation and reacted to other teams' second drafts. The instructor prompted teams to reflect on:

- Where is your draft and this point and how has it changed since the draft you shared in week 3?
- How has making Cacoo drafts and reflecting on the drafts help you move from discovery to design decisions or exploration to design commitment?
- How are your design drafts addressing what you have learned about Detroit Basket Works?
- How are your design drafts helping you focus on one intervention for the Basket Works?

Speaking with R. E. Keen resulted in some teams changing initial intervention ideas that were depicted in the first draft. In Blackboard, Jennifer reflected that initially she and her teammate Jack discussed that training was essential for Detroit Basket Works employees to learn new technologies for the basket making process. After the R. E. Keen discussion, Jennifer and Jack realized that all the workers have all the skills needed to weave quality baskets. Ultimately, Jennifer and Jack's intervention dealt with increasing effectiveness and efficiency in the packaging and shipping operations. Ken could relate to Jennifer and Jack. Ken commented, "We initially thought that one area of the organization was a problem, then found out that it was not." Although the R. E. Keen discussion led Ken and Darlene to explore a different path, the team took solace in that its first draft was easily adaptable to focus on a different area of Detroit Basket Works.

Having fixed draft milestones presented in WebEx and Blackboard encouraged teams to enhance previous ideas. Through feedback from the instructor and other teams and the structured opportunities to gather information regarding Detroit Basket Works context and constraints, teams expressed details about their interventions. In a Blackboard post, Bobby wrote:

At this point, we used the feedback from our class meeting and the interview with R. E. Keen to really start to dig deeper into the details of our proposed intervention. This

draft (#2) attempts to strike a balance by presenting visuals, while also providing the details of each activity within the intervention.

To conclude week 4, teams had the opportunity to "email" questions to R. E. Keen, Katie Gleason, Detroit Basket Works manager, and Gil Perreault, an artisan basket weaver. The instructor played the role of each Detroit Basket Works employee. This was the final opportunity for teams to glean any remaining information before finalizing intervention implementation design for the week 5 presentations. Since teams had to constantly reflect on new information coming in, the instructor made certain that teams had space to reflect and finalize their designs. The instructor concluded all feedback and scaffolding four days prior to the final presentation due date.

Week 5

Each team provided a 15-minute presentation of its final design. After each presentation, the instructor and students asked questions and commented on final intervention plans. Of the three design projects, the Detroit Basket Works intervention plan was the most complex and comprehensive. Teams had to implement a single intervention for Detroit Basket Works, which definitely required multiple performance interventions. Teams reflected that external representations clarified the context and constraints, which then resulted in an intervention that best fit within the context and constraints. Bobby elaborated, "I think that the external representation made it easier for the two of us to see where the design started to move past our constraints (requirement of one intervention) or the context of the situation presented."

As teams progressed from early design drafts to later design drafts, teams committed to their designs based on what they enhanced from prior drafts. External representations coupled with the reflection process supported teams to carefully measure ideas prior to proceeding to specific intervention decisions, Heather summed up the team's company-wide communication intervention:

The first draft in Cacoo focused on discovery. We looked at a myriad of issues related to the quality of baskets from production and sales to customer satisfaction. The second draft helped us focus on the results that we are trying to achieve for Detroit Basket Works. Artisan baskets are increasing in popularity, but Detroit Basket Works needs to focus on their production issues before they are able to increase production with projected growth in this area. The second draft enabled us to make design decisions for our intervention.

DISCUSSION

Our data across the three cases suggests that providing scaffolding that is agile and just-in-time while the design is taking place is critical to the success of student designers' problem solving and instructional design process. The key of employing scaffolding as an instructional strategy in our context of instructional design is to provide a student-centered experience and the ability to *jump in* and *step back* as the design progresses, meeting student designers' disparate needs across different learning stages. For example, during the Detroit Basket Works intervention plan project, the instructor role-played as the CEO and allowed designers to ask questions while providing ongoing feedback for students' draft designs. This intentionally scaffolded process prevented student designers from jumping straight into the solutions, as is often observed in inexperienced design students searching for a design solution as quickly as possible (Huybrechts et al., 2012). The authors believe that without such an agile type of scaffolding, the depth of reflections seen in student discussion posts and the quality of design products would have been greatly compromised.

Our data further suggests that enforcing a layered scaffolding structure helped student designers receive feedback and maximized opportunities for improving their design drafts. The instructor provided an ambient scaffolding that occurred at various points of the design process. The instructor also created an authentic learning environment where students can provide peer-to-peer support that is also considered part of the scaffolding between mediocre and advanced learners. Student designers within their own individual project groups can provide feedback for each other, while students across different groups can provide feedback reciprocally. This multi-layered structure ensured that guidance and support take place not only between the instructor and students, but also among peer students across different individuals and groups. Each iteration of the design draft builds upon the next, continuing to move toward an improved solution of the design problem. Such peer support provides new evidence for the existing literature, demonstrating that peer learners with a higher state of task mastery can support other individual learners when needed (Ge & Land, 2003; Nicol & Boyle, 2003).

Along with scaffolding, it appears that creating external representations promoted *a problem-solving space* for student designers where they can document and reflect on what is happening in the design and explicitly demonstrate their considerations of design rationale in various stages. External representations become the safe space where designers display different paths to design, while remaining open enough where new paths, relationships and ideas could emerge. The problem-solving space is critical for student designers to discover and provide solutions to the design problems, as a linearly progressing problem-solving process does not always exist in

design (Van Bruggen & Kirschener, 2003). The multi-layered scaffolding approach allowed student designers to maximize opportunities of gaining feedback for their external representations. At each step of the process, student designers engaged and interacted with rich external representations while accounting for the design context and searching design solutions.

Student designers experienced firsthand that multiple drafts emphasize opportunities for enhancement and help students hesitate from wanting to jump to a final design solution. Teams never discarded previous drafts. Teams enhanced previous drafts as they received more information that teams discovered and the instructor provided. Teams enhanced designs as the team received feedback from teammates, from other teams, and from the instructor. By interacting with external representations in a reflective and scaffolded design environment, students produced designs that exceeded the instructor's expectations.

Finally, the instructor's active participation cannot be emphasized enough. In the design environments presented here, the instructor, simultaneously, was a fellow designer, taskmaster, coach, cheerleader, actor (roleplaying R. E. Keen), perceived expert, scheduler, researcher, and teacher. Planning the design projects prior to the start of the semesters and visualizing how the design projects would progress were critical to the success. Piloting with the Foundations of Distance Education course helped with how to introduce Cacoo and provided a glimpse on the flow of the design project engagement and evolution.

CONCLUSION

In the pilot of the distance education time machine design project (Baaki & Luo, 2017), the authors credited the pilot success to the structured and guided elements of scaffolding blended into the design project process. In all three design projects, the instructor successfully provided students with ample opportunities to reflect-in-action when solving ill-structured problems. The instructor engaged students in practices and activities where students seamlessly designed and developed external representations. The instructor used scaffolding techniques via a learner-centered approach to highlight and reinforce collaborative learning by having students provide peer feedback. Through student self-reporting, the instructor's formative and summative evaluation, and the authors' close review of drafts, the design process resulted in final products that were refined and noticeably improved.

The authors conclude that creating and interacting with external representations is an effective way for inexperienced instructional designers to succeed in the design and problem-solving process. Rather than asking ad hoc questions when needed in

a traditional class setting, moments for discussion, reflection, and feedback were built in and allowed for as part of the design process. The instructor ensured there was an appropriate amount of support and assistance fixed in each design project. At the same time, the instructor was careful to make certain that teams had the space to make final reflections prior to the final design. Three to four days prior to the final presentations, the instructor ended scaffolding and feedback from other teams.

The present study offers insights from in-depth qualitative data across three cases verifying the affordances of providing scaffolding alongside external representations; however, the authors recognize that the study is not without limitations. As a qualitative study, the results and implications may only be applicable to alternative learning environments and settings similar to our own context. Furthermore, this study did not attempt to measure learning outcomes of any kind. In order to statistically demonstrate the effectiveness of scaffolding with external representations as an instructional strategy, experimental design research that compares the differences in learning outcomes between a control and experiment group may provide further insights. Future research may also consider utilizing a different sample other than IDT, such as investigating designers on-the-job or other design-related disciplines.

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