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Applying Merrill's First Principles of Instruction to Redesign an Online Graduate Course through the Rapid Prototyping Approach

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Abstract

Merrill's first principles of instruction (FPI) are considered as fundamental principles for improving instructional effectiveness regardless of context, approach, or audience. However, very little research explores in detail the process of implementing FPI in course design. In this case study, we provide specific descriptions of how we applied Merrill's FPI in an online course redesign project. Using the rapid prototyping approach, we analyzed the needs of the redesign project, developed the project objectives and plans, and conducted a parallel processes of design, development, and implementation of the new course features. Thirteen redesign tasks were identified, prioritized, and completed to enhance the application of FPI. Students indicated in the course evaluation forms that the redesigned course presented the connections between theories and practice more effectively. We discuss this study's implications for the application of FPI and the rapid prototyping model and make suggestions for future research.

Keywords Case study · Merrill's first principles of instruction · Online graduate course · Rapid prototyping

Introduction

With the rapid development of learning technologies, extensive changes are taking place in education (Alexander et al., 2019), which requires instructional designers to adjust to new and evolving situations on a regular basis (Sugar et al., 2012). Merrill's (2020) first principles of instruction (FPI) are particularly relevant for today's design practices since FPI includes a set of fundamental principles that can be applied to any instructional system to improve learning, regardless of the delivery mode or instructional approach. Past studies have investigated the application of Merrill's FPI in a variety of settings, such as face-to-face and flipped courses (Hall et al., 2020) and informal learning environments (Nelson, 2015). Evidence shows that implementing FPI can have a positive impact on learning outcomes (e.g., Frick et al., 2010; Lo et al., 2018). However, how FPI is applied for the design of

instruction and learning environments is unclear among the existing studies (e.g., Cheung & Hew, 2015; Hoffman, 2014; Lo & Hew, 2017). Scholars argue that studies that detail design processes are needed (e.g., Hall et al., 2020).

This research uses a case study method to provide a detailed account of how Merrill's FPI were applied to redesign an online graduate course, using a rapid prototyping model (Tripp & Bichelmeyer, 1990). A case study enables researchers to explore a phenomenon in depth and describes and analyzes rich data (Creswell, 2009). As investigators who were also involved in the redesign process, we took an insider's perspective (Patton, 2002) to retrospectively describe the case through analyzing the course design artifacts, project meeting minutes, designer's reflection notes, and student course evaluations.

Merrill's First Principles of Instruction

Through systematic reviews of a proliferation of instructional design theories and models (e.g., Reigeluth & Carr-Chellman, 2009), Merrill (2002, 2020) synthesized five fundamental design principles that promote effective, efficient, and engaging instruction. These principles, called the First Principles of Instruction (FPI), include:

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1. Demonstration: Learning is promoted when learners observe a demonstration of what is to be learned rather than merely receive information about what is to be learned.
2. Application: Learning is promoted when learners engage in the application of the newly acquired knowledge and skills.
3. Problem-centered: Learning is promoted when learners are engaged in solving real-world problems.
4. Activation: Learning is promoted when learners' relevant prior experiences are activated.
5. Integration: Learning is promoted when learners reflect on, discuss, and defend their newly learned skills, as well as transfer the skills into their everyday life.

Merrill's FPI emphasize contextualizing instruction based on authentic, real-world tasks. It is posited that instructional effectiveness will increase in proportion to the implementation of FPI, regardless of context, approach, or audience (Merrill, 2002). Merrill (2020) further suggested the successive application of FPI: Principle #1 Demonstration represents the first level of effectiveness, Principle #2 Application the second level, and Principle #3 Problem-centered the third. Adding Principle #4 Activation and Principle #5 Integration further improves the effectiveness of instruction. Numerous empirical studies support the efficacy of FPI. For example, Frick et al. (2009, 2010) developed an instrument for students to indicate whether FPI were used in the course and implemented the instrument with more than 600 students across about 100 undergraduate and graduate courses. Findings reveal correlations between the perceived implementation of FPI and student rating of instructor quality and course satisfaction (Frick et al., 2009). Additionally, if students agreed that their instructors used FPI and also that they experienced high academic learning time, they were about five times more likely to achieve high levels of mastery of course objectives (Frick et al., 2010). The positive effects of FPI are also found on student creativity (Jalilehvand, 2016), cognitive engagement (Lee & Koszalka, 2016), achievement in Chinese language, math, physics (Lo et al., 2018; Lo & Hew, 2017), and statistics (Tu & Snyder, 2017).

Another set of research studies have investigated the conditions and factors that impact the implementation of FPI. Rauchfuss (2010) explored the relationship between the uses of FPI and years of experience of instructional designers and discovered that novice and expert designers applied Principle #1 Demonstration equally, which is the first level of effectiveness (Merrill, 2020). But expert designers were more likely to achieve higher levels of effectiveness by applying the other principles (i.e., application, problem-centered, activation, integration). A possible reason is that novice designers are typically mediacentric, focusing on content demonstration and delivery rather than the effective incorporation of design models and strategies (Gibbons, 2003). Klein and

Mendenhall (2018) interviewed 15 members from a course design team that created 49 online modules within 11 weeks and found that the incorporation of FPI was impacted by a variety of factors such as project requirements, personnel, physical setting, training and team meetings, etc. They particularly pointed out that in addition to designer experience, time was another main factor that constrain designers' use of FPI (Gardner, 2011), since instructional designers are likely to eliminate certain tasks based on the project timeline (Wedman & Tessmer, 1993).

Very little research, however, explores in detail the process of implementing FPI. In some studies, it is unclear how the principles were applied to the course design or how the design instantiated the principles (e.g., Cheung & Hew, 2015; Hoffman, 2014). A more recent publication (Gardner et al., 2020) describes how a team of instructional designers and subject matter experts applied FPI to redesign an accelerated graduate course. The team employed a "systematic approach" (p. 498) where they first identified the learning outcomes, analyzed student performance data, developed real-world learning problems, and then designed and developed instructional materials before piloting the course. This research informs the current study as it identifies the design issues, such as "lack of examples" and "inadequate practice opportunities" (p. 499), and applies Merrill's FPI to address those issues in a master-level course similar to this study. However, as with many other projects (Desrosier, 2011; Klein & Mendenhall, 2018), the design work reported in this study, covering the initial stages of a large course redesign process, had a tight timeline and limited personnel resources, so applying the systematic process of analysis, design, development and implementation was not feasible. To address the project needs within the above constraints and fill the gap in the literature, this study employs the rapid prototyping model (Tripp & Bichelmeyer, 1990; more below) to redesign an online graduate course. Below we describe in detail the context, the process and results of the redesign project, followed by a discussion of the implications for instructional design and future research.

Course Context

The course in this redesign project is a three-credit-hour course, entitled "Instructional Design and Development." It is a required core course in a 100% online, asynchronous masters' program in instructional technology at a public university in a mid-Atlantic state. All program courses, including this course, have been converted from the face-to-face format to be offered online on a 7-weeks schedule using the Blackboard learning management system through whole program revisions. The students enrolled in this course are mostly full-time professionals seeking to advance their knowledge

and competencies in technology integration, media application, instructional design and training development.

Redesign Decision

The earlier version of the Instructional Design and Development course included readings, videos, discussion forums, weekly assignments and a final project. Between 2010 and spring 2020, this course has gone through numerous modifications (Cai & Robinson, 2021) to address the Quality Matters Rubric (Quality Matters Program, 2018) and Universal Design for Learning principles (CAST, 2018). During whole program revisions, the program committee agreed that it is pivotal for this course to guide students to develop foundational instructional design competencies through real-world experiences since instructional designers entering the workforce are expected to apply knowledge and skills to create design products and develop learning materials, applications and environments (AECT, 2012). The need for the course redesign also became evident due to the changing backgrounds of students. Originally, the course's primary audience was assumed to be K-12 educators. Over the past years, this course has been attracting an increasing number of students from other settings including the training industry, higher education, and the human resources development field. Additionally, analysis of students' feedback and their performance suggested that they needed more guidance and support to apply the instructional design models and principles learned from the course readings to their own contexts in order to complete the final project (Cai & Robinson, 2021).

Resources and Personnel

The department and the college supported the redesign decision. The course instructor received a 3-credit course release for working on the redesign project in fall 2020. The industry-leading authoring tools, including *Articulate* and *Adobe Captivate*, were purchased to create learning materials, activities and assessments. The course instructor is the lead designer and developer of the course. She was an instructional designer at both the k-12 and higher education levels for about 4 years and has been a university faculty member in the past 5 years, teaching and conducting research on instructional design, online pedagogy, and feedback design. The instructor has been teaching and making modifications to this course since fall 2019 (Cai & Robinson, 2021). The course instructor was also offered to work with an experienced learning designer who was involved as a peer reviewer throughout the redesign process. The role of the peer-expert learning designer was to meet with the course instructor regularly, review the design modifications, provide feedback, and discuss the next step. Furthermore, the course instructor

had an opportunity to present the course redesign for the program committee so as to collect faculty feedback and adjust design modifications.

Course Redesign Process

The entire course redesign project is planned to start in summer 2020 and end in summer 2021. This study reports the initial stages of the process from July 2020, approximately 1 month before the fall semester, to the end of fall 2020. The instructor was assigned to teach two sections of this course in fall 2020, one in the first 7-weeks of the semester, the other the second 7-weeks. This teaching schedule provided opportunities for the immediate implementation of the redesigned course so that the instructor could promptly discover the design and implementation challenges through observing learner experiences and performance. However, such a schedule challenged the instructor to perform the design and development tasks at a fast pace so they could be implemented in the fall. Notably, the existing course contains seven modules, each lasting 1 week. Modularity of the course "allowed a segment of the instructional unit to be added, removed, or modified without affecting severe interactions in the other segments" (Tripp & Bichelmeyer, 1990, p.38), making it practical to redesign the course quickly.

Given the above considerations, the instructor adopted an iterative design process adapted from the rapid prototyping model (Tripp & Bichelmeyer, 1990; see Fig. 1), which supports a flexible, fast-paced method instead of the exhaustive analysis of the traditional models. Before the fall semester started, the instructor spent about 4 weeks analyzing the course topics and content to develop the tentative objectives and plan for the redesign project. She also developed some course components to be released in the first week of the semester. When the course began, the instructor continued with the parallel processes of design, development, and implementation (Tripp & Bichelmeyer, 1990). She managed to stay about 1 week ahead of the course schedule, redesigning each module to be implemented in the next week. At the end of the first 7-weeks course, the instructor had 3 days to make a few minor changes before the course started again. During the second 7-weeks implementation, the instructor constantly reflected on the course design based on student experience and feedback and made modifications as much as possible. The end product of the redesign project is a modified 7-weeks online course, "an appropriate artifact" that can be further adapted to other situations (Tripp & Bichelmeyer, 1990, p. 38).

Fig. 1 Course redesign process
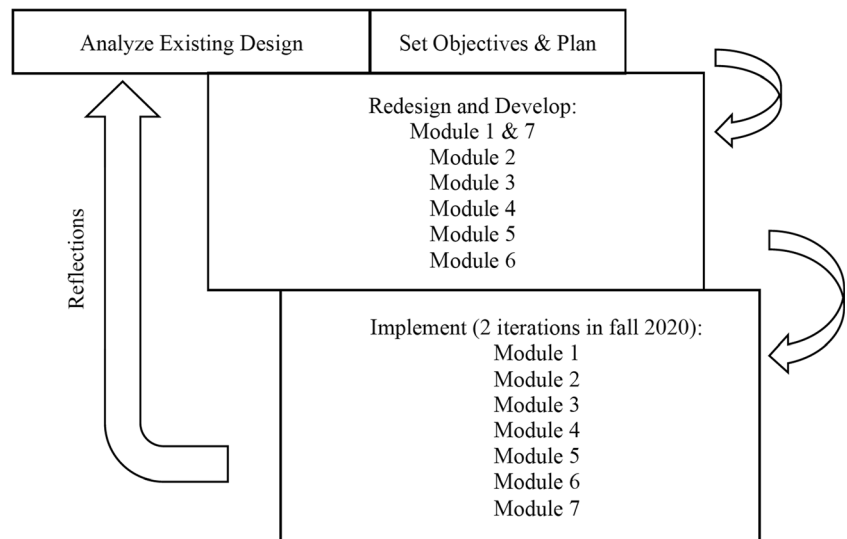
Analyze Existing Design

The course instructor first conducted a needs assessment, including a detailed examination of the existing course goals, assessments, and design features and an analysis of student feedback from the university's course evaluation forms from fall 2019 through summer 2020. An essential focus of this stage was to identify the areas where Merrill's FPI had been incorporated in the existing course.

This course provides an overview of instructional design. Among the nine course goals, three emphasize the conceptual understanding of learning theories and instructional design models (i.e., Knowledge Goals), four focus on the selection and design of materials, media formats and assessments based on the front-end analysis, such as needs analysis and task analysis (i.e., Design Goals), and the other two require learners develop prototypes of instructional strategies or learning environments (i.e., Development Goals). In the summer 2020 course, the most updated version before the redesign project, students demonstrated these learning goals through group discussions, individual reflections, and the final project. For Knowledge Goals, students worked in groups to discuss instructional design theories and models and analyze design cases. They also completed individual reflection assignments to demonstrate their understanding of the readings. For Design and Development Goals, students completed the final project where they conducted the key steps of instructional design, including needs analysis, learner analysis, task analysis, and created a plan for instructional strategies, materials, and assessments.

Merrill's (2020) FPI were addressed in some aspects of the existing course. Specifically, students were asked to identify and solve an authentic problem through their final project, which required real contexts, real audience and real learning challenges, such as difficult concepts or complicated

procedures with which their audience often struggle. The final project was divided into several portions to allow students to work on a progression of tasks throughout the course (Principle #3 Problem-centered). During the group discussions, students were prompted to reflect on their past experiences and make connections between their existing knowledge and the new ideas and skills (Principle #4 Activation). To support the final project process, students were provided with a few sample projects created by those who had taken the course before (Principle #1 Demonstration). Students could also practice instructional design tasks to receive instructor and peer feedback (Principle #2 Application). Finally, students would need to create an instructional plan that could be used in their own work settings (Principle #5 Integration).

However, not all FPI were implemented effectively. Principle #1 Demonstration was not thoroughly incorporated in the modules, where students focused on specific design tasks. For example, when analyzing a learning problem, students mostly relied on the book chapters, articles and text-based instructions from the instructor. The sample projects provided examples, but they only showed the end products instead of demonstrating how to perform the design tasks. Students shared in the course evaluations that the course could be enhanced with clearer explanations and examples.

Principle #2 Application was not adequately addressed, either. In the module on "task analysis" students were asked to reflect on an informal task analysis conducted in the past, instead of actually analyzing an authentic learning task related to their final project. Throughout the course, ungraded activities were implemented for students to develop drafts of the final project and receive formative feedback. Unsurprisingly, not all students took advantage of these practice opportunities. As Wiethe-Körprich and Bley's (2017) pointed out, students commonly dedicate little effort to low-stake

assessments to save their energy for meaningful academic tasks. One comment from the course evaluations revealed that the student considered these ungraded activities as "optional work" that added stress and unnecessary study hours, instead of opportunities to receive individual coaching from the instructor.

Additionally, the application of Principle #3 Problem-centered and Principle #4 Activation could be further enhanced, particularly at the beginning of the course. In the previous design, students were asked to read the final project instructions in Week 1 to see the entire learning task they were expected to accomplish at the end of the course. These instructions were presented using word documents (about 10 pages in total), listing the nine components students must address. However, the sequence of these components did not match that of the course modules (Table 2), making it difficult for learners to understand the final project is made of a progression of sub-problems and each sub-problem is sequentially addressed by each course module. The instructor had annotated the documents and created a video to make clarifications and address the common questions (Cai & Robinson, 2021). But students were still confused and asked for clearer and more concise directions. In Week 1, students also read the textbook to get an overview of instructional design, and then write a reflection on a design model that is most appealing to them. Unfortunately, the textbook content alone could hardly activate students' prior knowledge and skills as a foundation for new learning because the information was abstract and decontextualized (Merrill, 2020).

Based on the above analysis, the instructor concluded that FPI were addressed in certain aspects of the course, but not thoroughly. Several modules needed particular attention during the redesign process, as the implementation of Principle #1 Demonstration and Principle #2 Application was quite limited. The application of Principle #3 Problem-centered and Principle #4 Activation also needed to be improved. Considering the project timeline, the instructor identified and prioritized the following redesign goals/tasks and developed a tentative plan.

Redesign, Development and First Implementation

About 4 weeks before the fall 2020 semester, the redesign and development process began with Module 1 and Module 7. Module 1, introducing the course and the field of instructional design, would be released on Blackboard in Week 1 for students to complete. Module 7, providing the instructions and sample works for the final project, would also be posted in Week 1 so that students could see the whole design task and the end product they were expected to create (Principle #3 Problem-centered).

Task 1: Principle #1 Demonstration

According to the plan above, the course instructor used *Articulate Rise*, a web-based e-learning authoring tool, to develop a course website to supplement the existing instructions on Blackboard. For example, to address student feedback that some of them did not understand how the final project was related "to content taught in the course," the instructor developed a webpage showing an interactive learning map that organized the course elements into three threads: course readings, group discussions, and components of the final project. Hot spots on the learning map allowed learners to click and view how the elements were connected to each other (Fig. 2). The instructor also created a screencast video to explain the course's Blackboard site and its *Articulate Rise* website to orient students in Week 1.

Task 2: Principle #4 Activation

Another modification made to Module 1 was the incorporation of a case study discussion to replace the previous writing assignment. The case describes a situation that an instructional designer is hired to design professional development (PD) to support teachers' change efforts when a school is preparing to adopt a new curriculum. Many students in the course found the scenario familiar as their workplaces often implement new initiatives and require employees to complete PD programs. During the group discussions, students were prompted to think as the instructional designer in the case, reflecting on his design expertise, examining the existing PD process within the school, identifying the audience and the stakeholders, etc. As students investigated the role of instructional design in the real-world context through the case discussion, they were able to identify and share their own background knowledge and experiences that could support their learning in the course.

Redesign Task 3: Principle #3 Problem-Centered and Principle #1 Demonstration

Along with the case study, students were introduced to the final project during Week 1. The instructor re-aligned the course modules and the final project so that the progression of the final project's sub-problems was more saliently presented (Table 2): Students were first asked to identify and analyze a whole learning problem from their work contexts. They would then conduct a needs analysis and a learner analysis to determine if there is any gap in their audience's knowledge, skills, or performance. The results enabled them to select a focus area from the entire learning problem. Finally, students would perform a task analysis and design specific instructional content, strategies, assessments for the identified focus. Merrill (2020) suggests that, to address Principle #3 Problem-centered, it is best to have at least three
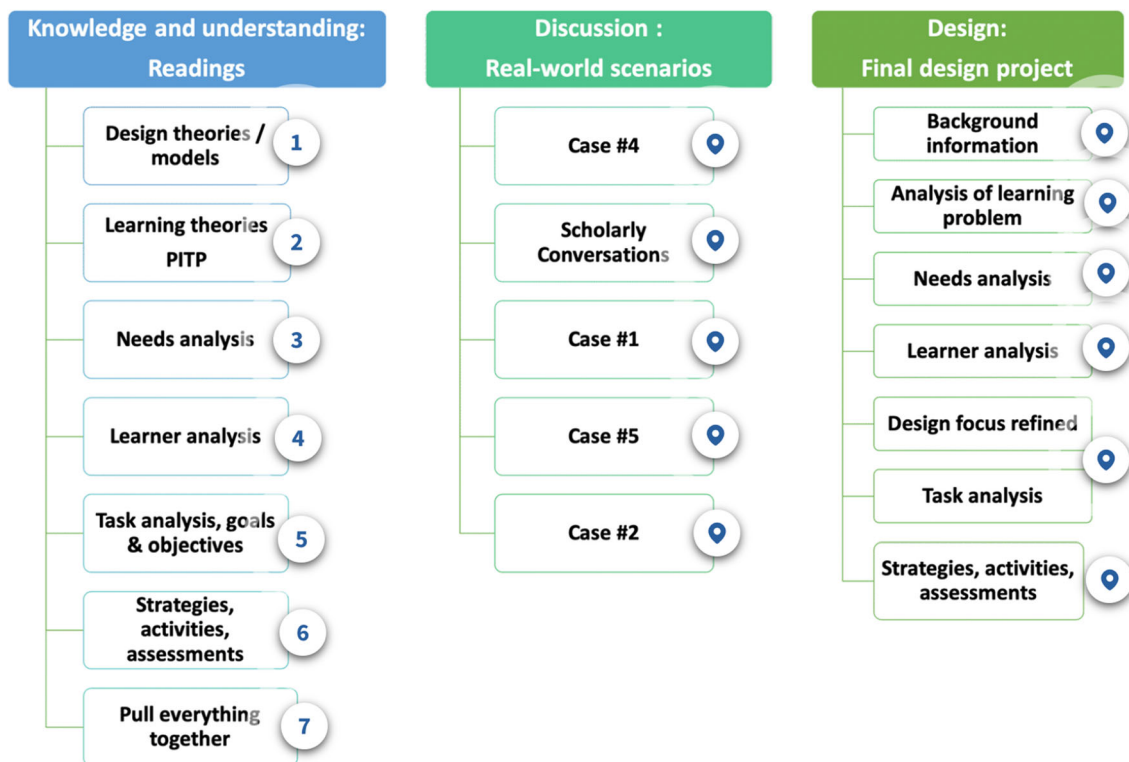
Fig. 2 Three threads of course elements

portrayals of the whole problem. However, we found it challenging to develop and demonstrate a series of whole problems within our project's timeline. As described above, we instead created a progression of sub-problems as partial tasks within the final project.

A webpage was developed as an alternative way to display the final project instructions. To enhance clarity and interactivity, the project description was shown under three tabs: overview, course objectives addressed, and grading. Underneath, the project components were explained using both text and images and were organized in an accordion (collapsible content) so that students could toggle between hiding and showing each component.

Task 4: Principle #2 Application and Principle #4 Activation

Module 1 ended with a graded assignment, replacing the previous ungraded activity where learners decided whether to share their final project topics. The new assignment asked students to identify an authentic learning problem for which they would like to design instruction. They would then apply what they've learned from the case discussion to analyze their design context, including their work environment and audience. In fall 2020, all students submitted the assignments and received specific individual feedback from the instructor. For those who needed major revisions, they were allowed to revise and resubmit. Essentially, this assignment, along with the other weekly assignments, provided practice opportunities for

students to solve a sequence of increasingly complex sub-problems constituting the final project and to receive formative feedback as they worked through the course.

Tasks 5–13: Principle #1 Demonstration and Principle # 2 Application

Once the fall 2020 course started, the instructor had limited time each week for the redesign project. To achieve efficiency, the instructor concentrated her design efforts on two areas: addressing Principle #1 Demonstration by developing examples of how to conduct the front-end analysis (Tasks 5, 7, 9, 11), and addressing Principle # 2 Application by creating graded assignments for students to practice the sub-problems of the final project (Tasks 6, 8, 10, 12).

The instructor used *Articulate Rise* to develop a webpage for each of the steps for the front-end analysis covered by Module 2 through 5. The webpage presents multimedia information, including text, graphics, and audio, to explain the instructional content. The objects on the screen, such as tabs, hot spots, image galleries, are interactive to allow learner control and guide their attention. The dynamic display is much more effective and engaging than merely reading text (Merrill, 2020). In addition to the instructions on how to conduct the front-end analysis, the instructor carefully crafted context-specific examples which served as portrayal content elements (Merrill, 2020). For example, in order to demonstrate needs analysis, the instructor selected students from the

courses she taught before and used the aggregated performance data to determine the learning gaps. The instructor not only described each step of the process, but also explained how she addressed the constraints in time and data availability, which are common challenges in an authentic design context.

After presenting the examples, the instructor designed a graded assignment for students to immediately apply the skills learned from each module. On the assignment instructions, students were reminded to review the scaffolding resources, particularly the webpages and examples, before starting the tasks. As students progressed from one module to another, the supporting materials developed by the instructor were gradually diminishing (see Table 3), shifting the control to the students and eventually leaving them on their own (Merrill, 2002). While the instructor spent less time developing the scaffolds, she made considerable efforts to provide individualized feedback to students. The instructor annotated each assignment to indicate where and how learners could improve. If a major confusion or misconception was identified, she wrote detailed explanations specific to the student's project context. The quote below shows a small portion of the instructor's feedback to one student on how to reorganize his analysis:

You're being very thoughtful and provided detailed explanations ... This is a complicated learning problem... Knowledge and skills required to address this learning problem could be sorted into two categories: [The] 1st category: Knowledge and skills related to technology (...log in, Schoology ... drawing tool, PebbleGo) .... These are technical skills, instead of content knowledge, so it's expected that they are not directly correlated with curriculum content standards. [The] 2nd category: knowledge and skills related to subject content (e.g., animals' habitats) and cognitive thinking... Like you said, these are correlated with curriculum standards.

During the last few weeks of the course, the instructor continued to provide individualized coaching to students as they worked through their final projects. She also briefly reviewed the redesigned components, such as the course webpages and the assignments, and edited the wording and formats to enhance clarity (Task 13).

Second Implementation

The course soon started for the second seven-week. This time, the instructor did not make major changes to the course design, but observed and collected information on students' course experiences. For example, the instructor took note of all the clarification questions students asked, as well as the concepts and assignments where students found difficult.

The instructor was also aware that redesign was still needed to increase opportunities for students to use the e-learning authoring tools to prototype learning solutions (Development Goals of the course). Therefore, she spent time exploring the industry-leading authoring tools, such as *Adobe Captivate*, as well as various digital applications commonly used by K-12 teachers, including *Pear Deck* and *Nearpod*, and planning for integrating these tools into the course. For example, based on student performance, the instructor identified "task analysis" as an area of struggle, and planned to create an interactive learning object using *Adobe Captivate* on this topic. She also revisited the final project and determined that instead of completing a paper-based design document (e.g., lesson plan), students could be asked to use the authoring tools to develop or prototype a learning product. Due to the time constraints, the instructor decided to begin these redesign tasks (integration of authoring tools) after fall 2020.

Results

In this study, we applied Merrill' FPI to improve the design of an online graduate course. During an 11-week period, we used the rapid prototyping approach to analyze the needs of the redesign project, develop the project objectives and plans, and conduct a parallel processes of design, development, and implementation of the new course features (Tripp & Bichelmeyer, 1990). At least 13 redesign tasks were completed to enhance the application of Merrill's FPI. Specifically, a course website was developed to display multimedia instructions and portrayal examples (Principle #1 Demonstration). A series of graded assignments were designed for students to apply what they learned from each module and receive individual coaching from the instructor (Principle #2 Application). The course components were realigned to show a progression of learning tasks for students to work through (see Table 2; Principle #3 Problem-centered). A case study discussion was implemented in the first week to activate students' prior experiences related to instructional design (Principle #4 Activation). During the course's second implementation, the instructor constantly made edits to the wording and formats of the course instructions to address student confusion immediately. She also identified areas that would need more considerable modifications and planned for the next stage of redesign, which involved developing an interactive learning object on "task analysis" and creating opportunities for students to use e-learning authoring tools or digital applications to prototype learning products.

On the course evaluation form, five items are analyzed to indicate student perceptions of the course design (see Table 4). The other items are excluded from the analysis because they focus on the course textbook and the instructor's online pedagogy (e.g., facilitation of online collaboration). The mean score of the five relevant items is higher in fall 2020 than summer 2020 but the difference is not statistically significant

Table 1 Course redesign plan for the first 7 weeks

Redesign Tasks	FPI Addressed or Enhanced	Completion Deadline	Implementation
1. Develop multimedia content to replace or supplement the existing text-based instructions in Module 1	#1 Demonstration	Before the start of fall 2020	Week 1
2. Design a case study discussion	#4 Activation		
3. Modify the final project instructions and realign course components to show a progression of sub-problems more explicitly	#3 Problem-centered #1 Demonstration		
4. Design a graded assignment for students to complete the first sub-problem of the final project: context analysis	#2 Application #4 Activation		
5. Modify instructions and develop an example to demonstrate how to analyze a learning problem	#1 Demonstration	End of Week 1	Week 2
6. Design a graded assignment for students to practice analyzing a learning problem	#2 Application		
7. Modify instructions and develop an example for needs analysis	#1 Demonstration	End of Week 2	Week 3
8. Design a graded assignment for students to practice needs analysis.	#2 Application		
9. Modify instructions and develop an example for learner analysis	#1 Demonstration	End of Week 3	Week 4
10. Design a graded assignment for students to practice learner analysis	#2 Application		
11. Modify instructions and develop an example for task analysis	#1 Demonstration	End of Week 4	Week 5
12. Design a graded assignment for students to practice task analysis	#2 Application		
13. Revisit the redesigned components and make modifications	If feasible and needed	Ongoing during Week 5–7	Week 5–7

(M_{fa} = 4.39, M_{su} = 4.12, p = .46). Particularly, students reported that the redesigned course did a significantly better job presenting the "connections between theory and authentic … experiences" (M_{fa} = 4.56, M_{su} = 3.58, p = .016). Students shared that the course was "extremely well organized" and "very applicable" to their jobs, and they enjoyed the "explicit examples" and the consistent formative feedback.

Discussion

This study contributes to the literature by providing detailed descriptions of how Merrill's FPI can be applied to improve the design of an online graduate course. Our design project reveals that addressing FPI requires sustained efforts. Before the redesign project, FPI had been implemented in the course to some extent. However, through a closer examination, we discovered several areas where FPI were not thoroughly applied. Through the two implementations of the redesigned course, we continued to identify the design issues that need to be addressed in the future.

While applying FPI involves long-term efforts, it was helpful to consider Merrill's (2020) levels of instructional effectiveness to prioritize the design tasks (Table 1) within the project timeline. According to Merrill (2020), successively providing an appropriate demonstration and an application to the instruction could produce a significant increase in learning. Therefore, we concentrated our efforts on the first two principles. Six (46%) of the 13 design tasks were related to Principle #1 Demonstration, illustrating the text-based instructions by developing multimedia content and portrayal examples to achieve the first level of instructional effectiveness. Five (38%) tasks involved Principle #2 Application, providing practice opportunities for students to apply the newly acquired

Table 2 Sequence of modules and final project components

Summer 2020		Fall 2020
Sequence of Modules	Sequence of Final Project Components	Sequence of Modules and Final Project Components - Realigned
1	1	1. Introduction
2	3–5	2. Analysis of Learning Problem
3	2	3. Needs Analysis
4	2	4. Learner Analysis
3	6	5. Task Analysis
5–7	7–9	6–7. Design specifications (content, strategies, assessments, etc.)

Table 3 Gradually diminished scaffolds

Module 2 Analysis of Learning Problem	Module 3 Needs Analysis	Module 4 Learner Analysis	Module 5 Task Analysis
1. Video explanation of the module reading 2. A complete portrayal example (Showing the essential process and the final results) 3. Template (with instructions)	1. One-slide overview of a needs analysis model 2. A complete portrayal example (Showing the essential process and the final results)	1. An *incomplete* portrayal example (Showing the essential process and the *partial* results).	1. Three portrayal examples of the task analysis results (*without* showing the process of how to conduct the task analysis)

skills and receive instructor's feedback, which improved the effectiveness to the second level. One task was about Principle #3 Problem-centered, which represents the third level of effectiveness; it was addressed by enhancing the alignment between the course modules and the final project components to show a problem progression. Two tasks were addressing Principle #4 Activation, adding additional effectiveness to the instruction.

This study also highlights the practicality of the rapid prototyping model (Tripp & Bichelmeyer, 1990). In contrast to the traditional instructional design models that emphasize linearity, complexity, and determinism (Dick et al., 2014), the rapid prototyping model allows for agile design and development decisions. It is particularly relevant to the current education context where there is an exponential growth in online programs (Crawley, 2012) that serve diverse student populations with different backgrounds and learning needs. The rapid prototyping approach replaces the exhaustive analysis of the traditional models with a few overlapping processes (Fig. 1), which enables designers to adapt or redesign the existing course features through a flexible, iterative, fast-paced method. Most notably, the rapid prototyping model

advocates a shift away from the "conquer-the objective mentality" and toward identifying precisely what the designer is trying to accomplish (Desrosier, 2011). This clearly matches Merrill's suggestion that instructional designers should avoid creating learning objectives early as they tend to change as the instruction is developed (Brown & Green, 2020). This redesign project shows that Merrill's FPI can be implemented using a rapid prototyping approach, supplementing the existing literature on the application of FPI through a systematic process (Gardner et al., 2020; Gardner & Jeon, 2009).

Last but not least, the redesigned course showed a significant improvement in presenting "connections between theory and authentic … experiences", although the mean score of the course design related items was not significantly higher after the redesign (see Table 4). This finding, aligned with previous empirical studies (e.g., Frick et al., 2009; Jalilehvand, 2016), affirms FPI's potential for improving instruction. It also helps establish the possible causal links between Merrill's FPI and the various student outcomes investigated in the past. Based on this study, it could be that the implementation of FPI helps learners understand how the course content connects to the authentic experiences, increasing the relevancy of the course,

Table 4 Course evaluation scores

	summer 2020 n=12	fall 2020 n=18	p value
	Mean (Standard deviation)		
Course design features demonstrate the following…			
Course learning objectives were clearly described…	4.50 (0.58)	4.44 (1.00)	.85
Assignments… reflected the primary content of this course as set out in the course learning objectives.	4.16 (0.91)	4.22 (1.16)	.88
The course was clearly organized.	3.91 (1.06)	4.28 (1.08)	.36
Connections between theory and authentic … experiences	3.58 (1.39)	4.56 (0.68)	.016
Different perspectives and alternative points of view	4.42 (0.74)	4.44 (0.92)	.95
All the above items	4.12 (0.94)	4.39 (0.97)	.46

which can improve student engagement or motivation (Lee & Koszalka, 2016) and ultimately learning achievement (e.g., Lo et al., 2018; Tu & Snyder, 2017).

In the future, we plan to implement FPI in more courses and study how to operationalize and apply FPI to generate positive impacts on student learning. It is necessary to identify the critical factors that affect the implementation of FPI and explore solutions to addressing those factors (Klein & Mendenhall, 2018). Since the direct empirical evidence on FPI's efficacy is still limited (Hall et al., 2020; Lee & Koszalka, 2016; Tiruneh et al., 2016), we also plan to conduct more rigorously designed evaluation research to determine FPI's effects in varied contexts.

Declarations

Human Participants and Informed Consent This study was conducted on already available data and the author received an IRB approval with Towson University.

Conflict of Interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

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