CATALOGING OPEN ONLINE LEARNING DESIGN PATTERNS FOR COMPUTER SCIENCE COURSES

By

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To my Mom and Dad

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LIST OF ABBREVIATIONS

MOOC	Massive Open Online Course
OER	Open Educational Resources

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
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This study was conducted for the purpose of developing a catalog of open online learning design patterns for computer science courses, a template for documenting and reusing successful design solutions. The study also sought to explore different approaches that contribute to the rich description of the catalog of design patterns. This work started with the mining of design patterns from Massive Open Online Courses (MOOCs). Design patterns are effective solutions to recurring problems that are useful for guiding design decisions. Reusability is the key element of design patterns, where the solutions can be used in many different contexts.

Merrill's First Principles of Instruction served as a theoretical framework in this study. First principles prescribe a task-centered approach that integrates the solving of problems encountered in real-world situations with a direct instruction of problem components. The fifteen design patterns presented in this study can be used in conjunction with other few principles for teaching materials and learning activities, such as the collaboration, interaction, motivation, and navigation in designing a quality open online learning for computer science courses. Besides, this study also proposed a template to the instructional design community on how to effectively document and

communicate design patterns in an open education context. Designers can use this template to express their design expertise to other instructional design professionals and also make use of design patterns in practice.

CHAPTER 1
INTRODUCTION

This study was conducted for the purpose of developing a catalog of open online learning design patterns for computer science courses, a template for documenting and reusing successful design solutions. The study also sought to explore different approaches that contribute to the rich description of the catalog of design patterns. This work started with the mining of design patterns from Massive Open Online Courses (MOOCs). Design patterns are effective solutions to recurring problems that are useful for guiding design decisions. Reusability is the key element of design patterns, where the solutions can be used in many different contexts.

Open online learning is a revolution in higher education that provides free online courses to anyone with access to the Internet (Wiley, 2015). Open online courses are typically designed around a self-guided format without personalized, one-to-one support from instructors that assumes learners can regulate their own learning (Milligan & Littlejohn, 2016). Due to open access and massive target audience, open online courses require different learning designs from those online courses that have small student numbers (Wiley, 2015).

Background

Design patterns in instructional design are general reusable solutions to a commonly occurring problem within a given context. A design pattern is a description or template for how to solve a problem that can be used in many different situations. Design patterns are formalized best practices that the instructional designer can use to solve common problems when designing an instructional system. One example of a commonly used documentation format is the one used by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides (1995), collectively known as the “Gang of Four” in their famous book *Design Patterns – Elements of Reusable Object-Oriented Software*. Christopher Alexander (1979) introduced the concept of design patterns to facilitate rigorous discourse in architecture, building, and planning. Alexander in his seminal book *The Timeless Way of Building* (1979) defined a pattern as an instruction that shows how the arrangement of elements can be used repeatedly to resolve the problem, provided the context is relevant.

Design links theory and practice, connecting scientific activities and creativity to deal with the uncertainty and complexity of open ended, ill-structured problems as found in the creation of learning technologies. Design knowledge differs from other types of knowledge. Design knowledge is a meta-knowledge that leans more toward the “methods leading to answers” than the “answers themselves” (Hoadley & Cox, 2009). Making tacit design knowledge explicit is extremely difficult, and conveying such knowledge is particularly challenging. According to Hoadley and Cox (2009, p. 19):

> …to get a better grip on what experienced designers know, in whatever sense of the word – come up with effective, reproducible ways of getting novices to a similar stage, such that they understand the general ideas that all expert designers share, and develop their own unique ways of understanding and applying those ideas.

Experts can be considered unique since it is not easy to explain exactly what is on their minds. It is hard to determine how things have been done previously and why they have been done in some certain way, as well as how to reuse those solutions. The field of knowledge engineering addresses exactly this issue (Gomez-Perez, Fernández-López, & Corcho, 2004). Building knowledge-based systems could be done by assembling reusable components rather than constructing them from scratch, enabling system developers to reuse and share knowledge-components, such as declarative knowledge, problem-solving approaches, and reasoning activities using a common vocabulary among systems (Gomez-Perez et al., 2004). Thus, system developers could concentrate on the creation of specialized knowledge of their systems. In their book, Gomez-Perez et al. (2004) focused on the ontology learning methods to reduce the effort of the knowledge acquisition process, preserve the original ontologies, and evaluate the ontology content.

In the study conducted by Chi, Feltovich, and Glaser (1981), the problem schemata of experts were clearly different from those of novices. In this study, experts categorized the problems based on the abstract physics principles, while novices characterized the problems according to the particular features (Chi et al., 1981). The categorization of problems based on the relevant principles will prompt the activation of problem schemata or particular knowledge structures that will determine which efficient solution to be used.

The evidence from research on expert-novice comparisons indicated that the experts relied mostly on the problem structures for determining the similarity of solutions, whereas the novices depended mainly on the surface structures (Hardiman, Dufresne, & Mestre, 1989). On the other hand, novices who took advantage of the principles had a tendency to categorize problems in the same way experts categorized them, and scored higher in problem solving. Due to these reasons, Hardiman et al. (1989) suggested to structure the information presented to novices in a way that assists them in organizing knowledge by principles, which in turn can lead to better understanding.

Groen and Patel (1985) carried out research in medical education and found experts used strong methods to address a specific type of problem, depending on a detailed and structured knowledge base. A main difference between experts and novices in solving problems was that the former tended to employ a form of forward reasoning of hypothetico-deductive thinking, while the latter engaged in backward reasoning (Groen & Patel, 1985). The forward reasoning approach involves applying a set of if-then production rules to a problem, generating a diagnosis without a hypothesis. In order to apply if-then rules, the clinician drew from his structured knowledge base. As a result, any comparison of expert and novice problem-solving models should consider the clinician's knowledge base and also its organization.

Overall, the studies of experts conclude that experts predominantly recognize the types of problems and already know the solution methods. Thus, there is a growing demand for documenting and communicating design knowledge in a systematic and structured manner. In the design literature, several methods are commonly used for capturing and sharing design knowledge, and one of them is through patterns.

Design patterns received considerable attention over the last three decades in various fields as a means for disseminating design knowledge to novice designers. Design patterns are reusable solutions to recurring problems that can be used in different contexts. Design patterns were first applied to the field of architecture in order to provide solutions to common problems encountered in the modern architectural design, such as the communities and neighborhood design (Alexander, 1979). The objective was to present this knowledge in a comprehensible and consistent form that could be reused by architects. Alexander (1979) proposed design patterns in a narrative form, providing textual descriptions and pictures that illustrate a design problem and its solution. In particular, Alexander (1979) suggested that, “Each pattern is a three-part rule, which expresses a relation between a certain context, a problem, and a solution” (p. 247). Alexander’s *The Timeless Way of Building* that was published in 1979 consists of 253 architecture design patterns.

Pattern documentation typically contains the causes of problems in a particular situation, and how the essential elements of the pattern relate to each other in order to provide the solution. For instance, Alexander et al. (1977) through the pattern “INDOOR SUNLIGHT” attempted to solve a “problem” of indoor sunlight from the point of view of thermal considerations, either to direct light all around the room or avoid the room overheats on summer afternoons. Instead of suggesting the designer to put how many windows in the room, a pattern would guide the designer in the decision-making process by proposing a set of solutions for the particular situation. The purpose of the pattern is to guide a designer, rather than prescribe. Thus, Alexander et al. (1977) suggested enough windows to allow the natural light to come in and keep the room bright and sunny, “A long east-west axis sets up a building to keep the heat in during winter, and to keep the heat out during the summer. This makes buildings more pleasant, and cheaper to run” (p. 616). Further, their “solution” as follows:

> Place the most important rooms along the south edge of the building, and spread the building out along the east-west axis. Fine tune the arrangement so that the proper rooms are exposed to the south-east and the south-west sun. For example: give the common area a full southern exposure, bedrooms south-east, porch south-west. For most climates, this means the shape of the building is elongated east-west. (Alexander et al., 1977, p. 617)

Alexander et al. (1977) considered this suggestion as the best solution because daylighting creates a positive home environment and makes the home a more enjoyable place. Also, Alexander et al. (1977) described the applicability of the pattern due to a broad range of housing types. The situations in which a pattern can be applied is known as a “context,” such as single-detached, semi-detached, townhouses, and apartments. In another example, Alexander et al. (1977) considered both bus stops and waiting area for children in a pediatric clinic are within the “context” for the pattern named “A PLACE TO WAIT.” The “problem” description of this pattern was to create a positive waiting (for a bus, for an appointment, for a plane) situation. Thus, the “solution” proposed was to provide the waiting areas with newspaper, coffee, pool tables, and something that draws people in who are not merely waiting. The opposite “solution” was to create a place that can be enough to make people daydream while waiting, “The right atmosphere will come naturally if the waiting area provides some places that are quiet, protected, and do not draw out the anxiety of the wait” (Alexander et al., 1977, p. 710).

The greatest impact of design patterns can be seen within the field of software engineering. According to the data from the Scopus publication database, design pattern was among the topics that had the highest number of papers published in the area of software engineering (Garousi & Mäntylä, 2016). Expert designers generally do not solve each problem from the first principles. When they found some solutions that worked really well, they began to use them repeatedly. Such experience makes them experts and could be documented as design patterns. Gamma, Helms, Johnson, and Vlissides (1995) introduced a template for describing and organizing design patterns in object-oriented software design using a consistent format that includes four main elements, namely, pattern name, problem, solution, and consequences. Further, Gamma et al. (1995) proposed a catalog of object-oriented software design patterns that contains 23 patterns. Similarly, Chung, Hong, Lin, Prabaker, Landay, and Liu (2004) described that design patterns are different from other design formats, such as guidelines and heuristics in capturing design knowledge. The difference between design patterns and guidelines are: (1) Design patterns provide abstract solutions to the more general problems, rather than presenting specific solutions (Hoadley & Cox, 2009), (2) Design patterns provide examples of actual designs, helping designers produce new solutions (Chung et al., 2004), and (3) Design patterns are interrelated with others in a hierarchy structure, allowing designers to address both high-level and low-level problems (Gamma et al., 1995).

The concept of design patterns can be applied not only to support architects and software engineers, but also can be used to guide instructional designers in designing online courses. Design patterns have been used in the field of education as a way to capture, share and reuse effective learning solutions, as well as to maintain an up-to-date record of best practices. Retalis, Georgiakakis, and Dimitriadis (2006) believed that design patterns do not describe a concrete design or specific design solutions, but they are just a template for how to solve complex problems which applies to different, but related situations, providing an abstract description of a design problem and the way to solve it.

Kolfschoten, Lukosch, Verbraeck, Valentin, and de Vreede (2010) found that design patterns are a practical way to transfer knowledge, presenting *ready-made* solutions to designers. The study by Kolfschoten et al. (2010) also discovered that design patterns do not only increase understanding of the design process among novices, but also increase the efficiency, flexibility, and reusability of the design effort.

Kohls and Uttecht (2009) conducted a case study on the mining, writing, and application of patterns for interactive educational graphics. Further, Kohls and Uttecht (2009) claimed that the most significant attribute of design patterns is they document actual design instead of abstract solutions.

Design patterns have been useful in many fields, ranging from architecture and software engineering to education and others. Indeed, there was some work on them in online course development, but there is a need for a comprehensive catalogue that can be used and shared within the instructional design community.

Context

The purpose of this study was to develop a comprehensive catalog of open online learning design patterns for computer science courses as an effective means of capturing and sharing successful solutions for recurring problems. The other goal of this study was to provide a template that designers can use to express their design expertise to other instructional design professionals. This solution should provide the instructional design community with a necessary template on how to effectively document and communicate design patterns in the field of open online learning.
The use of design patterns is significant as it allows the reusability of expert knowledge within open online education. As a scholar, I hope to answer certain questions related to the adoption of the design pattern concept in this study.

Professional Background

My current role is that of a faculty member at a public research university in Malaysia that has recently implemented and integrated massive open online courses with on-campus courses. The first stage of the initiative began with compulsory courses and learners from public universities in Malaysia participated in those courses. Coming from a computer science background, I am always interested in the design and development of technology enhanced learning environments. I constantly seek to learn about new approaches to create effective and engaging online learning environments towards meaningful learning among learners. Through the design and development of the catalog of design patterns, I have had the opportunity to speak with expert instructional designers who have designed, developed, and delivered open online learning for computer science courses. Also, I have explored different approaches that contributed to the rich description of the catalog of design patterns, from the self-observation, to the analysis of the functionality of computer science MOOCs, to the review of the literature on pedagogical strategies, and the study of existing published patterns in other related areas.

Current Challenges

One of the most emerging challenges as a novice instructional designer is to effectively design a large number of high quality courses. In order to create dynamic and innovative online learning environments, it is critical to allow the reuse of expert knowledge that a novice instructional designer can adopt when they design, develop, and deliver massive open online courses. Since the university at which I am employed has implemented a national MOOC program, instructional designers set about finding the right approaches to provide learners with a transformative learning experience, as well as to increase the accessibility and quality of higher education within Malaysia. I now seek to understand the approach of open online education more holistically from the perspective of an expert instructional designer.

Future Difficulty

Designing a high-quality MOOC requires a number of roles that are generally filled by an instructional designer, including course developer, instructor, and subject matter expert. Thus, another overarching challenge is my desire to assist novice instructional designers through providing a catalog of design patterns in designing effective learning modules that can be reused in different contexts, creating an engaging community experience.

Rationale for the Computer Science MOOCs

Coursera, edX, and Udacity are among outstanding MOOC platforms that provide high quality computer science and technology education. Almost every topic in computer science, such as game development, Java/Python programming, and machine learning is covered in those MOOC platforms. Since MOOCs are generally offered by the world leading universities, the courses are the same ones as given on those prestigious institutions and are taught by the same professors. Lectures on these MOOC platforms are structured quite different from regular online courses. The lectures are comprised of multiple short videos, typically 3-5 minutes in length with a series of quizzes. This approach keeps the learner engaged and interested in the topic at-hand. Some MOOCs are created in collaboration with industry partners such as AT&T, Amazon, Facebook, and Google. These companies have identified relevant skills that can be used in a job setting and built a pipeline of high-potential employees. Learners are required to complete a series of projects, and the feedback received on those projects is exceptional.

Justification on the Reinvent New Solutions

Instructional designers can use design patterns to solve problems that arise as they designing their solutions. Design Patterns are reusable solutions to recurring problems within a given context. It is important to note that more than likely, someone has already solved the problems that instructional designers encounter when designing open online courses. Thus, there is no reason for instructional designers reinvent the wheel each time they design a new open online course. The more they use design patterns, the easier it will be to solve new problems.

Problem Statement

Design patterns provide a format for capturing and communicating design knowledge among practitioners. The use of design patterns that are often cited include: act as a design tool, provide for accurate and concise communication among designers, and convey expert knowledge to novices. In the meantime, the emergence of Massive Open Online Courses (MOOCs) has generated a new and broad interest in open online learning. This growing trend in higher education has emphasized the capabilities and challenges related to the design of such learning settings (Chapman, Goodman, Jawitz, & Deacon, 2016). The instructional design community, including practitioners and researchers have dealt with the design challenges due to the continuous development of open online courses. Many different approaches are available for the functionality, pedagogy, delivery, and support of open online learning. Some have been successful and others have ended in failure. Thus, there is an urgent need to effectively document and communicate design knowledge in this field. Open online learning has its roots in the traditional online and distance learning, and this study was expanding the effort through design patterns for solving problems that are generated by teaching and learning at such a massive scale.

The enrollment of MOOCs has grown exponentially and the enrolled students in some courses had exceeded 230,000 (Jordan, 2014). Coursera, edX, and Udacity have appeared as the largest MOOCs platforms that offered more than 1,000 online courses (Lin, Lin, & Hung, 2015). Despite gaining popularity, issues have arisen regarding open online learning, for instance, high dropout rates, low completion rates, and low student engagement (Chen & Chen, 2015; Ferguson, Clow, Beale, Cooper, Morris, Bayne, & Woodgate, 2015). Some of the possible explanations for such student behavior were poor course content design (Margaryan, Bianco, & Littlejohn, 2015) and confusing learning interfaces (Lin et al., 2015). Although MOOCs have opened up education to millions of learners, these massive courses have been plagued by extremely high dropout rates. Findings of Stich and Reeves (2017) revealed that MOOC dropout rates as high as 90%. Online learning usually requires learners to be independent and able to deal with technologies used, and thus, lack of digital skills that leads to learners' confusion and frustration is one of the reasons for high dropout rates.

Liyanagunawardena, Adams, and Williams (2013) focused on the completion rates, progression, and retention of MOOCs, which could provide a better understanding of all participants, but give a little insight into an individual's behavior. More research is required, which focuses on individual learners as MOOCs embrace the diversity of learner experiences through the concept of openness. Jordan (2014) claimed the vast majority of learners who registered for the MOOCs failed to complete the course. Chapman, Goodman, Jawitz, and Deacon (2016) reported that MOOC poor completion rates typically below 10% of signups. Similarly, Stich and Reeves (2017) stated that MOOC completion rates are between 5% and 12%. Some learners may enroll without fully understanding the course requirements, such as prerequisites for those that are more advanced, and for those that are introductory but still require certain background knowledge or skill level (Stich & Reeves, 2017). Other learners may have unrealistic expectations of what they can achieve throughout the course, and take much more time to master the learning materials. The "one size fits all" format of MOOCs may not satisfy all individual needs due to the diversity of learner backgrounds.

Milligan and Littlejohn (2014) highlighted the importance for learners to monitor, control or self-regulate their own learning due to the non-existence of face-to-face interaction with MOOC instructors and other learners. Open entry encourages informal enrollment, particularly professionals for advancing a current job (Stich & Reeves, 2017), for instance to learn more about the MOOCs format as a way to produce their own courses, and some because of curiosity and enjoyment, as well as personal challenge rather than to gain understanding of the subject itself (Breslow, Pritchard, DeBoer, Stump, Ho, & Seaton, 2013). In their paper on instructional design quality of MOOCs, Margaryan, Bianco, and Littlejohn (2015) discovered that most course designs concentrate on the presentation of learning material instead of an interaction or feedback involving massive numbers of participants. Learner retention is an effective way to measure a success of MOOC as those who persevere in the course have an opportunity of obtaining the educational benefits. Hone and El Said (2016) conducted a survey to explore the factors affecting MOOC retention. The study revealed two significant predictors of retention in MOOC, namely the course content and interaction with the instructors.

Dating back to 2009, Fini claimed that MOOCs are nothing more than just traditional face-to-face courses, but using technology to support teaching and learning at scale, such as video-recorded lectures. The findings of this study enlightened how higher education institutions misuse a MOOC format as they relied upon traditional teaching methods that failed to leverage the benefits of an open platform. The author suggested to investigate the profile of the participants of MOOCs for further research as those associated with learning outcomes and retention. According to Gibbons (2010), one of the main criticisms of technology-based learning was the lack of human interaction in certain aspects of a course design that were required to stimulate student engagement, the key to academic motivation, persistence, and course completion (Devlin, Feldhaus, & Bentrem, 2013). The design of online courses directly influences learning outcomes (Kauffman, 2015) and some of them already addressed problems related to course content design and the learning interface. Ruey (2010) investigated whether learners benefit from an online course based on constructivist instructional strategies, for instance, virtual group projects, peer moderated discussions, and chat room meetings. The findings of the study revealed that this approach increased self-directed learning skills and interaction among learners through peer collaboration, as well as influenced learners' positive perceptions of online learning (Ruey, 2010). Instead of focusing on grades, learners became more interested in their learning, but constructive feedback and appropriate facilitation from the instructor were significant to achieve online course quality.

In some cases, the same project found it difficult to replicate their previous successful experience. For instance, Carnegie Learning produced the well-known intelligent tutoring system for high school mathematics based on human cognition, Cognitive Tutor Algebra, which was then followed by Cognitive Tutor Geometry. However, the findings showed that Cognitive Tutor Geometry was not as effective and successful as Cognitive Tutor Algebra (Bibi, 2010; Cen, Koedinger, & Junker, 2007; Pane, McCaffrey, Slaughter, Steele, & Ikemoto, 2010; Steenbergen-Hu & Cooper, 2013). Thus, codification of best design solutions into a set of best practices is important to transfer the past related experience of managing similar situations in the future.

Ideally, the development of open online courses should be pedagogically driven, instead of technology driven. When designing debates for an online course, for instance, the instructional designers should be mindful of the pedagogical issues, including reflection, interpersonal, flexibility, and teamwork skill development (Retalis et al., 2006). However, the design of usable and pedagogically effective learning environments is very challenging as it requires a significant amount of expertise and creativity, which could be a complicated task for novice designers who lack of experience (Frizell & Hubscher, 2002). Past experiences and best practices are bound up with tacit knowledge and difficult to transfer to another person, but sometimes could be shared through design guidelines or observation and practice with expert instructional designers.

Design patterns capture effective and successful design solutions that can be reused in different contexts, as well as could mediate and transfer design knowledge of experts to novices. The practical use of design patterns in open online learning specifically on computer science courses is yet to be formalized if compared to other domains, particularly architecture and software engineering. Instructional designers of online courses, especially novices could exploit design expertise and past experience of others to avoid reinventing solutions in their design effort (Retalis et al., 2006). Hence, there is a demand for a more structured method for documenting and describing design patterns best practices in designing open online courses. Also, it is significant in making design patterns explicit and available to the instructional design community and become a common practice.

Research Questions

The primary research questions addressed by this study were:

1. To what extent do the design patterns exist within the Massive Open Online Courses (MOOCs) in computer science?
2. How is a catalog of design patterns for open online learning constructed?

Research Design

This research was designed as a two-phase study.

Phase 1 focused on the design pattern mining and described how to derive patterns for open online learning. Ideally, the best source would have been successful and high-quality open online courses, specifically MOOCs. MOOCs are primarily offered by elite universities such as Stanford, Harvard, Berkeley, and MIT, and are taught by the same professors that teach in those prominent campuses. MOOCs provide an opportunity for instructional designers to learn best practices from others. Computer science is one of the most popular subjects on MOOCs, and dozens of computer science-related topics are available for the undergraduate and graduate levels. There are many instructional strategies designed to help learners understand the core concepts of computer science. After identifying the platforms, design patterns of the most popular topics of computer science MOOCs were mined. In this study, design patterns of MOOCs were mined through five methods: (1) Self-observation, (2) Expert interview, (3) Analysis of the functionality of computer science MOOCs, (4) Review of the literature on pedagogical strategies, and (5) Learn from existing published patterns in other related areas.

In particular, I searched for the recurring and meaningful design patterns. Instead of providing facts, design patterns describe the design experience in a more descriptive way. I focused on the practicality of design patterns since the goal of design patterns was the description of reusable solutions to recurring problems. Each design pattern was not isolated, but it was interrelated to other design patterns in the catalog. Experts' experience involved interviewing instructional designers to explore their experiences, expertise, and knowledge in designing open online courses. Themes emerged from qualitative analysis of the interviews were recorded. Information from the pattern mining approaches were used to inform the catalog of design patterns. Design patterns consist of instructional strategies generalized from a number of successful design cases or best-practices.

During Phase 2, design patterns were described and organized in a standard format. Design patterns are a tool for documenting and reusing previous solutions. Cataloging design patterns was performed in a formal way. This study used a template that was modified from the Gamma, Helms, Johnson, and Vlissides (1995) and Alexander (1979) pattern structures to describe and organize design patterns. Each design pattern was named, explained and described systematically. A qualitative approach was used to analyze the data. More details on the specific qualitative technique is given in Chapter 3. The process of integrating the findings and the catalog of design patterns is provided in Chapter 4.

Significance of the Study

Design patterns have appeared as a way to capture the design experience and knowledge of experts and deliver design solutions to others, including inexperienced ones. Design patterns do not describe a particular concrete design. Instead, the design solutions are just a template that can be used in many different situations, providing an abstract description of a design problem and how to solve it. Having the capability of capturing and communicating design expertise not only allows for the reuse of design knowledge, but also can save cost and resources, as well as helping to get the right design faster. Furthermore, only a few articles that discuss ways of identifying design patterns have appeared in the literature.

This study presented a set of instructional design knowledge that was based on general reusable solutions for recurring problems to design open online courses. The results of this study could provide both expert and novice instructional designers a method to create high quality designs, as well as suggested functionalities for more advanced and productive design approaches. In other words, this study had important implications for practice. The catalog of design patterns developed in this study could assist instructional designers to design better quality of open online courses, enabling them to learn from past successes and failures of others, instead of reinventing solutions that others have struggled to develop. However, instructional designers need to be creative because each design problem has both common and new/unique parts. The catalog of design patterns helps instructional designers to solve the common problems and release resources to solve the new problems.

Definition of Terms

Design pattern: A general reusable solution to a recurring problem within a particular context, as well as an approach for capturing, representing, and sharing design knowledge (Alexander, 1979)

Design pattern catalog: A documented collection of related design patterns with a consistent format (Gamma et al., 1995)

Explicit knowledge: Codified or written knowledge and usually represented by scientific literature (Yoshikawa, 1993)

Instructional designer: An individual that is responsible for designing instruction, performing and organizing work plan, and managing the overall aspects of the instructional design process (Koszalka et al., 2013)

Massive Open Online Course (MOOC): An online course that is designed for open access through the web and unlimited participation (Milligan & Littlejohn, 2016)

Open online learning: A free access and delivery of educational content and instruction through the use of computer and communication technologies (Stockley, 2003)

Pattern language: A structure for design patterns within a particular domain that creates common understanding among practitioners, researchers and learners in exploring and sharing their ideas about successful teaching and learning (Alexander, 1979)

Tacit knowledge: Knowledge acquired through practice and direct experience, highly pragmatic and context-specific, and typically shared through interactive conversation (Yoshikawa, 1993)

Organization of Study

This study is organized into another five chapters and appendices. Chapter 2 introduces the history of open education, open online learning, instructional designers, knowledge management, explicit and tacit knowledge, presents the theoretical framework of the study, and reviews of the relevant literature on design pattern research in education. Chapter 3 provides the research methodology. Chapter 4 discusses the analysis of the analysis of data mining, interview transcripts and preselection survey results, findings, and the catalog of design patterns for open online learning. Chapter 5 presents the summary of the study, discussion, and implications of the findings, and also recommendations for the future research. Finally, the appendices include interview questions, examples of the interview transcript, survey instrument, and list of references.

CHAPTER 2
LITERATURE REVIEW

Advances in technology have provided new opportunities for radically new models of online education (Milligan & Littlejohn, 2016). Since 2012, many universities have begun venturing into MOOCs as ways to provide cost-effective access to education (Margaryan, Bianco, & Littlejohn, 2015). There are various different approaches to the design of open online courses, some have been very successful and others are not. Apparently from the literature, the instructional designer community is struggling with the design issues due to the accelerated expansion in open online education (Wang & Baker, 2015; White, Davis, Dickens, Leon, & Sanchez Vera, 2015; Zheng, Rosson, Shih, and Carroll, 2015). It is interesting to see researchers expanding their research on traditional online education into open online learning, and sharing design knowledge could solve particular challenges associated with teaching and learning at scale.

Open Education

The concept of open education dates back to 1969 when the Open University of the UK was established, and admitting students in 1971 (Wiley, 2015). In the context of higher education, the term “open” refers to “open entry” due to a policy that allows anyone to enroll in courses irrespective of their educational background. In recent years, the adjective “open” describes an “open license” to make teaching materials available at no cost to the public (Wiley, 2015). This open license gives a person or organization permission to retain, reuse, revise, remix, and redistribute all the materials used in teaching without payment and copyright infringement. Canvas, Moodle, and

Sakai are some examples of learning infrastructure technologies that are created under open licenses.

The conception of open licensing in supporting open education brought up a new idea of “open educational resources” (OER), started with the MIT’s Open Courseware initiative in 2001 (Hewlett Foundation, 2016). In 2002, William and Flora Hewlett Foundation started investing in OER to provide high-quality materials for teaching, learning, and research that are free and accessible to people around the globe. Hewlett Foundation specifically defines OER as:

> Open Educational Resources are teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and repurposing by others. Open Educational Resources include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials, or techniques used to support access to knowledge. (Hewlett Foundation, 2016)

The evolution of OER can be traced back to the mid-1990s, when the idea of open learning objects spread through education communities. Wiley (2002) defined learning objects as reusable digital resources deliver over the Internet to support learning, such as video, audio, image, and animation. The main characteristics of learning objects are interoperable with any system or delivery tool, reusable in various learning events, accessible, and manageable media contents. The movement continued to the open courseware and open textbook initiatives in the early 2000s (Hanley, 2015).

Open Online Learning

Online learning is the delivery of an educational program, training or learning through electronic medium, which also known as e-learning, distance learning or online training (Stockley, 2003). Campus universities have largely used online learning as a complement to face-to-face instruction, while open universities tend to apply models of distance education for the delivery of digital content (Milligan & Littlejohn, 2016). At the same time, open education is seen as a solution for expanding access to affordable learning (Hanley, 2015). Massive Open Online Courses (MOOCs) are a unique form of online learning that allow for the capacity of courses to enroll large numbers of learners to participate at no or minimum cost with an adequate Internet connection. MOOCs are a part of the ongoing evolution of open education initiatives for serving growing and diverse learners through the use of technology to mediate pedagogical interactions, as well as to create and distribute educational contents.

MOOCs, however, are particularly different from other conventional online learning models in terms of scale and openness. The term “massive” aimed at unlimited participation and open enrollment (Hanley, 2015), also to track vast quantities of performance data and participant activity (Phan, McNeil, & Robin, 2016). “Open” refers to open access for learners regardless of their academic qualifications (Milligan & Littlejohn, 2016), while materials for the course are mostly free and accessible to all learners through the Internet on a variety of devices. “Course” means a time period with a start and a finish date to address particular learning objectives, followed by a sequence of activities organized by an instructor while offering a coherent resource set. To provide scalable solutions and cost-effective access, MOOCs are typically designed based upon self-regulation that assumes learners are able to control their own learning, instead of just depending on instructor guidance (Milligan & Littlejohn, 2016).

According to Phan, McNeil, and Robin (2016), classification of MOOCs may vary depending on the course content structure, expectations of the learners’ performance and methods of assessment. Content-based MOOCs or xMOOCs are typically designed around a modular video-lectures format, followed by additional readings, assignments, multiple-choice questions, as well as peer-graded and auto-graded quizzes for assessing learners' mastery of knowledge (Margaryan et al., 2015). Also, online discussion forums on xMOOCs enable active participation among learners, allowing the exchange of knowledge and ideas to create global learning communities (Hanley, 2015). In contrast, connectivist MOOCs or cMOOCs focus on an overarching instructional goal and are less directive with respect to process. These cMOOCs give more attention on exploration and discussion, instead of focusing on instructor-provided content (Margaryan et al., 2015). Using a variety of media resources or text-based, instructors may pose weekly questions to the learners, while learners usually develop their knowledge through collaborative learning with peers.

Instructional Designer

Instructional designers often engage in the analysis, design, development, implementation, and evaluation of instruction to provide successful learning experiences for learners in a wide variety of settings, ranging from K-12 environments to higher education. Koszalka, Russ-Eft, and Reiser (2013) suggested instructional designers show their competencies by applying systemic thinking practices and selecting a sound instructional design and development tools in order to maintain the quality of instructional solutions**.** "As a profession, it consists of a series of well-defined competencies, and an active group of practitioners who work in increasingly complex and sophisticated environments" (Richey, Klein, & Tracey, 2011, p. 1).

The International Board of Standards for Training, Performance and Instruction (ibstpi) published the most complete and recent version of statements defining a competent instructional designer (Koszalka et al.**,** 2013). According to ibstpi**,** an instructional designer must be knowledgeable in the design sciences (i.e., assessment, message, visual), project management, production processes, collaborative activities, as well as emerging technologies to prepare themselves in facilitating different types of learning (Koszalka et al., 2013). However, it is important to note that those knowledge and skills are useful to support instructional designers with the competencies when designing and creating instruction, not to turn themselves into information technology or production specialists.

Ritzhaupt and Kumar (2015) interviewed higher education instructional designers from across the United States to discover the essential knowledge and skills for success in their roles. All participants were reported to have graduate degrees in education with a concentration in either instructional design, instructional technology, instructional systems design, educational technology, learning technologies or multimedia design. Most participants stated that those academic degrees had prepared them well for the jobs and provided them with the knowledge of instructional design models and processes, learning environments, multimedia development, and communication design, in which they were able to apply in their current tasks.

In general, an instructional designer is described as having mastery of the learning theories, instructional design models, also possesses soft and hard skills (Ritzhaupt & Martin, 2014). Also, instructional designers should always be willing to learn on the job and keeping abreast of emerging technologies. Instructional designers are interacting one-to-one with subject matter experts and working closely with a technical team, such as programmers, graphic artists, animators and audiovisual specialists. With a good understanding of the learner's needs under the guidance of the subject matter experts, instructional designers can create an instructional blueprint to be successfully implemented by the technical members. Although the instructional designer is a highly demanding job, Retalis et al. (2006) believed that novices are coming into the field do not need a lot of experience to be hired if they could exploit design knowledge and expertise of others to avoid reinventing solutions in their design effort.

Subject Matter Experts

While the role of instructional designers is to design courses, the role of subject matter experts is to provide expertise in a defined area. After analyzing the learner needs**,** instructional designers prepare the course specifications, define the learning scope and objectives, as well as decide on the assessment method. Subject matter experts are typically not the ones creating a course, but they share their knowledge, propose the contents that should be covered, identify the resources, and ensure the accuracy of the learning materials prepared by the instructional designer (Keppell, 2000). Subject matter experts have a tendency to forget about sharing important information when the content is too common to them. Thus, instructional designers should catch the situation, reminding subject matter experts to provide examples and elaboration to the learners. Subject matter experts should work together with instructional designers to create a reliable and well-integrated instructional system. In other words, the collaboration between subject matter experts and instructional designers is necessary to produce a course with accurate content, as well as to provide an assessment that is fair, consistent, and free of bias. In some cases, an instructional designer need to be a subject matter expert.

There are two major components of course design: the human part and the technical part. The human component requires subject matter experts to work closely with instructional designers to successfully produce the desired or intended result. The design and development of instructional system require a team with a diverse range of skills to successfully complete all aspects of a module. The technical component of course design can be guided by the well-defined processes in terms of translating the content into a form that embodies the sound educational design (Keppell, 2000). The design and development of instructional systems often require instructional designers to assist subject matter experts in creating suitable teaching and learning resources. Subject matter experts are well versed in their area of expertise, but often are not familiar with the learning process. Similarly, instructional designers know the science of learning very well, but are not always familiar with the subject matter. Creating a common language between subject matter experts and instructional designers is necessary, particularly when important issues arise. According to Keppell (2000), the knowledge map could assist to focus the attention of the subject matter experts and instructional designers on the most crucial elements of the content.

Epistemology of Design

Design is a broad concept and can be classified into three stages: (1) Design as activity, (2) Design as planning, and (3) Design as epistemology. The classification of design consists of a conceptual structure that can define the epistemology of design, linking relevant scientific endeavors with engineering activities (Mahdjoubi, 2003). Design as activity is related to the pre-execution or conceptualization stages for creating new products that can be organized into two major components: “form” and “function” (Mahdjoubi, 2003). Applied art/industrial design, architecture, engineering, and fine art are some examples of the academic disciplines and professional fields for design as activity. Fine art is mainly about “form,” engineering on the other hand is associated with the “function” part. Both architecture and industrial design are a balance between “form” and “function.” Design of devices and systems for human use relates to the psychological and physical characteristics of human beings.

Design as planning is regarded as the pre-execution or conceptualization stages of planning, strategizing, and decision making, as well as systematic thinking prior to execution (Mahdjoubi, 2003). In other words, design as planning is a visualization for subsequent implementation. This design stage requires an interdisciplinary approach in a wide range of fields, including art, business, industry, management, and military. While design as activity is associated with professional endeavors such as architecture or engineering, design as planning is more towards integrating the managerial and strategic aspects of design.

Design as epistemology is related to the synthetic methodologies of execution (Mahdjoubi, 2003). The epistemology of design can also be referred to as science of design. Since the ancient Greeks, the main goal of science has been the exploration of truth. Design, on the other hand, is mostly about synthesis and how things should be. One can think of epistemology of design as a method for art, change, and strategy, while science is based on analytical research. Apparently, the discussion on epistemology of design and analytic methodology can be linked with the study of knowledge management.

Niehaves (2007) however, had a different viewpoint about epistemology. Niehaves (2007) claimed that epistemology is associated with how to achieve “true knowledge” and this concept is inevitably intertwined with the design science research. While design practice seeks to apply existing knowledge, design science research is concerned mainly with adding new knowledge to the body of knowledge. While Hevner, March, Park, and Sudha (2004) argued that design science research is another paradigm besides interpretivism and positivism, Niehaves (2007) argued that epistemological assumptions are fundamental to the design science research and greatly impact the execution and evaluation of such research.

Table 2-1. Although the design science research guidelines (Hevner et al., 2004)

Guideline	Description
Guideline 1: Design as an artifact	Design science research must produce a viable artifact in the form of a construct, model, method, or instantiation.
Guideline 2: Problem relevance	The objective of design science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design evaluation	The utility, quality, and efficacy of a design artifact must be demonstrated rigorously by means of well-executed evaluation methods
Guideline 4: Research contribution	Effective design science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.
Guideline 5: Research rigor	Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a search process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of research	Design science research must be presented effectively both to technology-oriented and management-oriented audiences.

Hevner et al. (2004) developed a set of guidelines on how to conduct and evaluate design science research as in Table 2-1. The design science research guidelines were proposed with the aim of achieving and evaluating design knowledge, for instance, design models, methods, processes, theories, or executions in a consistent way (Hevner et al., 2004). Although the design science research guidelines were developed specifically for the information system discipline, they are applicable to related design disciplines. Hevner et al. (2004) believed that a researcher can make a contribution to the body of design knowledge by applying these guidelines in a rigorous manner.

Design Knowledge

There are many definitions available for design given by different authors. Carrara, Kalay, and Novembri (1992) described design as a creative process that specifies the required actions to be taken in order to achieve particular goals. According to Koh, Ha, Kim, Rho, and Lee (2003), design is not only creating a new product or part of it, but also synthesizing pre-existing designs in an efficient way. Richey et al. (2011) claimed that a design contains factual knowledge that related to many topics, for instance the definitions of a learning hierarchy and mental model. Yokigawa (1993) stated that a design process starts with vague or unclear descriptions of the design object until they gradually become more comprehensive. Yokigawa (1993) further concluded "This indicated that a design process is a typical ill-defined and ill-structured problem that needs a cognitive approach to observe and describe it" (p. 133).

Since there is no formal method or procedure for such effort, the design is basically exploratory in nature – actions are hypothesized and the results are evaluated against the predefined goals (Carrara et al., 1992). Designers, of course, depend on their knowledge to effectively accomplish this exploratory process. The subjective sources of design knowledge are the designer's personal view of external realities, including past experience, perceptions, belief, preferences, and feelings (Carrara et al., 1992). The objective sources of design knowledge are the attainment of truth based on scientific research and theory for solving problems (Richey et al., 2011).

There are two key principles in the design literature: (1) Good design is generally iterative, and (2) The design can be enhanced through multiple iterations with each iteration continuously being improved until an optimal solution is reached. In the context of learning technology, iteration involves some form of feedback, such as course evaluation, learner assessment, or quiz to achieve improved design solutions. Hoadley and Cox (2009) suggested two main themes of the design: (1) Observing good and bad examples; and (2) Putting design method into appropriate practice. Given that design knowledge is more toward "methods leading to solutions" (Hoadley & Cox, 2009), novice designers should consider applying those fundamental design principles in managing the complexity of problems in the creation of learning technologies. Also, an effective design is not easy to get right the first time. Compared to experienced designers, novices are often overwhelmed with many design options. Experienced designers sometimes come out with good designs.

Design knowledge is different from other types of knowledge, and thus it should be delivered differently from other disciplines. In order to convey design knowledge, it is important to understand how novices can acquire it (Hoadley & Cox, 2009). Indeed, it is challenging to find an easy way for novices to understand the right design solution. Experts are unique and have different approaches. Although experts familiar with the subject, they have difficulty in communicating design knowledge to novices. In short, there is no optimal solution to solve design problems. For instance, one can document the recurring solutions of Frank Lloyd Wright's work, the greatest American architect of all time (Brewster, 2004), however, it is not easy to replicate his success, not only the novices, but also the experts. Design knowledge is hard to identify, but it does exist and can be shared within the design community, so novices can develop their own understanding by applying those solutions.

Knowledge Management

Managing knowledge is important in any discipline. Knowledge management is a process to improve the performance of organizations through the use of information and knowledge (Sallis & Jones, 2002). Bhusry and Ranjan (2012) defined knowledge management as the management of knowledge related to organizational goals and objectives. The successful management of knowledge helps organizations to deliver value-added products and services, thus it is crucial to promote the deployment and sharing of knowledge within the organization (Bhusry & Ranjan, 2012). Knowledge management plays a fundamental role as a survival strategy for any type of organization, including educational institutions as a way to strengthen their performance (Sallis & Jones, 2002).

Sallis and Jones (2002) claimed that sound knowledge management not only could enhance the effectiveness and efficiency of business or technology companies, but also could allow educational institutions to improve the learning of their learners and staff. Knowledge is dynamic and ever-changing, what was previously important could be outdated and obsolete (Koh et al., 2003). Further, Sallis and Jones (2002) claimed, "Some knowledge is very easy to access and cheap to harness, while other knowledge is locked away in people's minds and harder to use effectively" (p. 4). The initiatives of knowledge management in organizations are intended to develop intelligence and achieve improved performance and high productivity level.

Knowledge should be accessed and exchanged efficiently within the team. The other reason for managing knowledge is to retain knowledge and experience when designers resign or retire. For instance, some instructional designers had worked for almost five years in the same educational institution and in other cases, for over 10 years. Resigning designers are sometimes replaced with novices. The novice instructional designers need more time to build up experience, and thus there is a demand to capture, store and reuse expert knowledge. The motivations for knowledge reuse are to allow others search for previous solutions when working on a similar design problem, and enable existing designers understand the rational behind the decisions made earlier. Besides, instructional designers could validate or justify their design decisions based on previous experience (Ahmed, 2005). Due to these reasons, it is important for the educational institution to have a retrieval system with a high flexibility mechanism (Koh et al., 2003) to support the knowledge reuse.

The goal of a knowledge management system is to capture, store, structure, and share organizational knowledge. Bhusry and Ranjan (2012) stated that the development of institutional repository or known as a database is crucial to capture, store, index, maintain, and distribute all of the knowledge bases in digital formats. Hence, teaching materials such as lecture notes, presentation slides, question banks, simulation games, role plays, videos, and audios can be made available on the Internet, and further can be utilized by faculty in course preparation. A central repository not only allows easy access to knowledge, but also improved validity of knowledge and easy to trace the source of knowledge. Overall, the development of a knowledge management system can facilitate the promotion of institutional value in the competitive academic society (Bhusry & Ranjan, 2012).

Explicit Knowledge and Tacit Knowledge

Within knowledge management, two types of knowledge are often discussed, namely explicit knowledge and tacit knowledge (Koh et al., 2003). Explicit knowledge or "knowing that" are codified knowledge, such as those found in databases, documents, and notes. "Codified knowledge is a form of knowledge that is described with symbols, figures, and so on" (Yoshikawa, 1993, p. 133). Scientific knowledge mostly falls into this category. On the other hand, tacit knowledge or "knowing how" are non-codified knowledge rooted in attitudes, background, cultural beliefs, experience, practice, and values (Richey, Klein, & Tracey, 2011). Yoshikawa (1993) claimed, "Tacit knowledge is a form of knowledge that is explicitly or implicitly recognized by human and used for reasoning, but very difficult to describe" (p. 133). Expertise and skill are basically composed of tacit knowledge.

In practice, all knowledge is a combination of both explicit and tacit elements. The transfer processes for explicit and tacit knowledge are different, in terms of their conditions, methods, pace, and supporting mechanisms. Since explicit knowledge is formally documented, it can be easily captured, stored, and retrieved. This knowledge can be handled efficiently by knowledge management system, facilitating the process of reviewing, storing, modification, and retrieval of documents. Conversely, tacit knowledge is very hard to capture and convey since it resides in the mind of the practitioner. Tacit knowledge is transferred mostly through socialization, mentoring, observations, and face-to-face interactions.

Compared to explicit knowledge, tacit knowledge is regarded as the most valuable asset to the organization, and less focus on it could reduce the ability to sustain competitive advantage (Koh et al., 2003). To handle tacit knowledge is indeed challenging even with the help of knowledge management systems. It would be near impossible to express our intuitive understanding gained through years of practice and experience. An expert instructional designer, for instance, will solve a design problem based on his experience. It would be very hard for the designer to convey his knowledge into a document that could codify the “know-how” to a novice.

What are Design Guidelines, Design Patterns, and Design Principles?

Design knowledge can be documented in many different ways. Design guidelines, design patterns, and design principles are widely known forms of design guidance that may help solve some design problems. Novices often have difficulties in understanding and applying design knowledge to a particular problem. Selecting the most appropriate alternative is often based on evaluating certain advantages and disadvantages of the various design options. For each design problem, there are various alternative solutions for designers to choose from. A good design solution is about balancing between needs and constraints.

Design guidelines are the most concrete form of design guidance. Design guidelines are written at a low level of abstraction, so they can be applied in a specific context. Stewart and Travis (2003) defined guidelines as suggestions of good practice that depend on the author as an expert on a particular topic. In practice, design guidelines require design trade-offs as they may conflict with each other. However, design guidelines are difficult to apply in other different contexts as they provide detailed instruction (Gould & Lewis, 1985).

Design patterns are descriptive, normative, and communicative, and are designed to provide general solutions to recurring problems that can be reused in different learning contexts (Kolfschoten et al., 2010). Pescio (1997, p. 130) suggested, "it is easier to demonstrate knowledge by doing (show-how), and most people can also make good choices between alternatives (say-what)." Designers could find recurring design problems, identify the solutions that worked well, and capture their essence in a pattern (Pescio, 1997). Design patterns provide examples of how the solution approach can be used to assist novice designers in interpreting the guidance. It is important to consider various relations between single design patterns, instead of isolated solutions. However, there is no standard procedure to extract design patterns as they are fuzzy and hard to capture (Kohls & Uttecht, 2009). The recorded patterns usually differ not only in content, but also in style, depending on the designers who design the pattern. Some designers may concentrate on didactics issues, others may be more focus on structures. Design patterns are useful in translating requirements to specific design solution, while design guidelines are more useful to describe requirements. Apart from that, design patterns focus on the effectiveness of design solutions in a specific context, but design guidelines generally assume an absolute validity.

Design principles describe a rule to be followed to achieve a particular situation (Hoadley & Cox, 2009). Compared to design guidelines and design patterns, design principles are the most abstract form of design guidance. If patterns represent the "show-how" approach to design, principles are the "say-what" way (Pescio, 1997).

Design principles are design goals that are written at a high level of abstraction. Those principles can be applied in any context, but do not provide concrete design guidance. For instance, Gould and Lewis (1985) in their study suggested general design principles for system usability that include involvement with users, empirical measurement, and iterative design. Designers have to interpret, refine, and extend design principles in order to use them in a specific context. However, the practical use of design principles in the design process can be increased by specifying general principles at a low level of abstraction. The formal example of design principle is the International Standards Organization (ISO) 9241 for user interface design. Pescio (1997, p.130) claimed, "... a principle often provides no guidance toward a design that respects the principle itself. This makes principles-driven design somewhat hard to practice successfully unless you have considerable experience."

Research on Design Patterns

Design is about finding solutions to problems within predefined constraints, yet designers usually reinvent new solutions (Hoadley & Cox, 2009). Thus, it is difficult to determine how things have been done previously, and why they have been done in some certain way, and how to reuse solutions. Design patterns are just like theories that are subjected to empirical tests (Kolfschoten et al., 2010). The purpose of most design pattern research is to provide a method for capturing and communicating design knowledge in a field.

The concept of design patterns came from architecture (Alexander, 1979) and Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, and Angel (1977, p. x) said,

> Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem,

> in such a way you can use this solution a million times over, without ever doing it the same way twice.

After almost two decades, design patterns have been successfully used in software engineering. Gamma et al. (1995) adopted the idea of design patterns and applied it to the object-oriented software design. Gamma et al. (1995) described design patterns in their influential book, *Design Patterns – Elements of Reusable Object-Oriented Software* as,

> Design patterns are not about designs such as linked lists and hash tables that can be encoded in classes and reused as is. Nor are they complex, domain-specific designs for an entire application or subsystem. The design patterns in this book are descriptions of communicating objects and classes that are customized to solve a general problem in a particular context. (Gamma et al., 1995, p. 3)

Similarly, in the field of manufacturing, Brandl explained (2007, p. 11): "A design pattern is not a design. Instead, a design pattern is a template for how to solve complex problems that applies to different, but related, situations. A design pattern can be transformed directly into implementation." There are four essential elements of a design pattern as shown in Figure 2-1.

Pattern Name: A descriptive and unique name for identifying and referring the pattern.
Context: An explanation of the origins and context of the problem.
Problem: A brief description and scenario of the design problem at hand.
Solution: A description of the solution proposed by this pattern that addresses the problem and context.

Figure 2-1. Four essential elements of a design pattern

Expert designers can facilitate design knowledge by assisting novices to identify and apply patterns. Novices can establish a way to classify problems and identify important patterns for certain types of solutions. As mentioned earlier, patterns contain generalizable solutions to common problems, hence expert designers can use pattern templates to assist novices establish ways of recognizing particular problems and their general solutions. These patterns, however, should be more abstract instead of specific solutions. Novices usually start to understand how the patterns work by recognizing the recurring solutions in a particular context, trying to apply those solutions in some cases, and noticing the relevance of each pattern (Hoadley & Cox, 2009).

Design Pattern Usage

The main benefits of design pattern usage are often cited are: (1) Provide a template to effectively document and communicate design expertise to other designers, (2) Disseminate design expertise, best practices and knowledge to novices, and (3) Serve as a teaching and learning tool. According to Alexander (1979) and Gamma et al. (1995), reusability of solutions is the essential element of design patterns. There are two commonly used terms that are synonyms for design patterns: (1) A catalog of design patterns – a set of pattern that has a relatively low level of structure and classification (Gamma et al., 1995), and (2) A pattern language – coherent and interrelated design patterns that can be used to solve problems in a specific domain (Alexander, 1979).

A pattern language is a hierarchy of design patterns that is structured by scope, and the relations between the individual patterns are clearly marked (Borchers, 2001). Alexander (1979) developed a hierarchical pattern language, known as a hierarchy of problems to show the implementation order of related design patterns from top to down (Borchers, 2001). This approach assists designers to discover an appropriate solution to a particular design problem and indicate useful combinations with related patterns. Design patterns have been used to capture and share design knowledge between practitioners (Chung et al., 2004), and have been disseminated to novice designers in many domains, such as architecture, software engineering, human computer interaction, and education.

Design Patterns in Architecture

The objective of design patterns in this field was to provide design solutions to recurring problems encountered in the modern architectural design, and to present this knowledge in a comprehensible and consistent form that could be reused by architects. Alexander (1979) asserted that design patterns are a narrative form, involving textual descriptions and pictures that illustrate a design problem and its solution. In particular, architecture design patterns consist of 253 patterns, supporting architects in designing the modern architectural structures, such as the communities and neighborhood design. The development of those architecture design patterns was based on observation, analysis, and abstraction of implemented design solutions.

Design Patterns in Software Engineering

The concept of design patterns is very well-known in object-oriented software design. There are four main elements of a design pattern: pattern name, problem, solution, and consequences (Gamma et al., 1995). The pattern name is a description of a problem, its solutions, and consequences. The problem is a description when to apply the pattern that describes the problem, its context, and a list of conditions. The solution describes the relationships, responsibilities, and collaborations of the elements that make up the design. The consequences are the outcomes and trade-offs from the pattern application. Figure 2-2 shows a template for describing and organizing design patterns in object-oriented software design using a consistent format (Gamma et al., 1995). The catalog of design patterns by Gamma et al. (1995) contains 23 design patterns.

Pattern Name: The pattern's name conveys the essence of the pattern succinctly. A good name is vital, because it will become part of your design vocabulary.

Intent: A short statement that answers the following questions: What does the design pattern do? What is its rationale and intent? What particular design issue or problem does it address?

Also Known As: Other well-known names for the pattern, if any.

Motivation: A scenario that illustrates a design problem and how the class and object structures in the pattern solve the problem. The scenario will help you understand the more abstract description of the pattern that follows.

Applicability: What are the situations in which the design pattern can be applied? What are examples of poor designs that the pattern can address? How can you recognize these situations?

Structure: A graphical representation of the classes in the pattern using a notation based on the Object Modeling Technique. We also use interaction diagrams to illustrate sequences of requests and collaborations between objects.

Participants: The classes and/or objects participating in the design pattern and their responsibilities.

Collaborations: How the participants collaborate to carry out their responsibilities.

Consequences: How does the pattern support its objectives? What are the trade-offs and results of using the pattern? What aspect of system structure does it let you vary independently?

Implementation: What pitfalls, hints or techniques should you be aware of when implementing the pattern? Are there language-specific issues?

Sample Code: Code fragments that illustrate how you might implement the pattern in C++ or Smalltalk.

Known Uses: Examples of the pattern found in real systems. We include at least two examples from different domains.

Related Patterns: What design patterns are closely related to this one? What are the important differences? With which other patterns should this one be used?

Figure 2-2. Describing design patterns (Gamma et al., 1995)

Design Patterns in Education

Instead of providing design support to architects, software engineers, and manufacturers, design patterns are also a promising approach for instructional designers to express their design expertise to other instructional design professionals. In creating design patterns, focus is given to the forces acting on the problem and the reason for selecting a specific solution. Some patterns are thoroughly explored and elaborated through several years of research, while others are still new. Alexander, the founder of design patterns denoted asterixes (*) to indicate the difference between mature and immature patterns (Baggetun, Rusman, & Poggi, 2004). The classification of design patterns into mature and immature patterns fits nicely with instructional design, in which there are already established knowledge about instructional solutions, and also immature ones that need to be explored through further research.

Design patterns have been used in the field of education as a means to capture, reuse, and share design expertise and best practices. Design patterns are general reusable solutions to commonly recurring problems within a given context, based on the collaboration between experts and professionals in the education community. The objectives of design patterns in education are threefold (Bokhorst, Moskaliuk, & Cress, 2014; Borchers, 2001; Kolfschoten, Lukosch, Verbraeck, Valentin, & de Vreede, 2010): (1) As a teaching tool to help students in obtaining design knowledge and skills, (2) To capture knowledge from learning theories, instructional design models, expert best practices, and experiences for assisting student learning, and (3) To improve the quality of instructional systems.

Design patterns are relatively new in the context of open online learning, and available patterns currently focus on blended learning (Derntl & Motschnig-Pitrik, 2005), cognitive learning (Kolfschoten, Lukosch, Verbraeck, Valentin, & Vreede, 2010), collaborative learning (Persico, Pozzi, & Sarti, 2009; Zitter, Kinkhorst, Simons, & Cate, 2009), e-learning (Retalis et al., 2006), and learning management systems (McAndrew, Goodyear, & Dalziel, 2006). Besides, there are also design patterns that focus on courseware production (Yang, Moore, & Burton, 1995), human computer interaction (Kohls & Uttecht, 2009), learning object design (Chikh, 2014), and mobile learning user interface (Al-Samarraie & Ahmad, 2016). Yet, none of them published a comprehensive catalog of design patterns for open online learning specifically in computer science.

Design patterns for human computer interaction

Kohls and Uttecht (2009) presented a case study on the mining, writing, and application of patterns for interactive educational graphics. The authors emphasized on the pattern mining and explained how to obtain patterns from experience and analysis. Drawing on schema theory, the authors conducted an empirical study to investigate whether different people perceive the same patterns. Kohls and Uttecht claimed that patterns are vague and hard to capture because individuals may have different patterns in their minds. Consequently, the captured patterns differ not only in content, but in writing style as well, depending on the patent authors. Kohls and Uttecht asserted that a significant attribute of design patterns is that they document real design, rather than concepts evolve from theories. Kohls and Uttecht made the important distinction between: (1) The patterns in the real world, (2) The patterns in the human mind, and (3) The documented patterns. However, the authors stated that the most challenging task is to capture patterns in a standard way since there is no agreed procedure to deal with the pattern mining.

Design patterns for collaborative learning

Zitter et al. (2009) suggested a theoretical framework that is based on graphical and textual representations, known as a task conceptualization, which adds new insights into the process of creating design patterns. A task conceptualization consists of elements of activity theory, boundary objects, collaboration scripts, and scaffolding to facilitate the process of redesign e-learning environments. The authors selected the authentic task as a core concept and adopted the concept of the role and event to highlight the practical and concrete aspects of organizing meetings and sessions for learners. The authors also chose the concept of boundary object to add a particular analytical viewpoint as well as the concept of scaffolding. The properly designed roles, events and boundary objects provide learners with a necessary support to perform a task. The task conceptualization helps to develop valuable design patterns, specifically when redesigning online courses that involves theories and approaches, in which the task conceptualization turns out to be generic enough to handle the concepts that already in used.

Design patterns for cognitive learning

Kolfschoten et al. (2010) developed design patterns to teach undergraduate students in designing simulation and computer programming related courses. Design patterns can be viewed as a practical way to transfer knowledge as they provide “ready-made” solutions. The authors argued that design patterns do not only increase understanding of the design process among novices, but also increase the efficiency, flexibility, and reusability of the design effort. The authors analyzed the concept of design patterns in relation to the cognitive load theory to explain how information can be presented to learners in ways that enables them to use the human brain capacity optimally for learning and comprehension. The authors found that novices working without design patterns really struggled than those working with design patterns. Their findings suggested that design patterns allow novices to build solutions that have an acceptable quality, as well as have the potential to reduce the design and development cost. Apart from that, it seems design patterns are more helpful in establishing a nonlinear knowledge representation and transferring that knowledge to new situations. Another reason for the impact of design patterns on knowledge transfer could be the pattern's inherent structure reduces cognitive load. The authors concluded that design patterns are useful for novice learners, while practice problems are better for more experienced learners. The results clearly showed that experienced learners did not benefit from the learning effect of the design patterns as "the experts ran into a conflict between their own mental patterns and the design patterns offered to them, resulting in additional cognitive load" (p. 657). However, in certain circumstances, experts might benefit from the use of design patterns as a baseline to which they can compare their own solutions.

Design patterns for mobile learning user interface

Al-Samarraie and Ahmad (2016) developed design patterns for mobile learning user interface as a solution to design problems and improve user experience. The authors established 71 design patterns and divided them into seven categories: dealing with data, providing input, navigation, notifications, personalization, screen interaction, and social activities. The authors then investigated the relationships between the design patterns and the learning activities. Their findings provided evidence that the use of design patterns differed between right- and left-hand-dominant participants with regard to reading, information retrieval, and information-browsing tasks. These results could guide designers to consider suitable design patterns for promoting learning activities based on hand dominance.

Design patterns for open learning

Warburton and Mor (2015) constructed and evaluated the MOOCs design patterns by means of a shepherding process through three intensive workshops. The design patterns were developed from shared narratives of successful practice with experts in the field of online learning that used to develop and deliver MOOCs. Five dimensions of MOOCs design patterns are: orientation, participation, learning, community, and management, with 20 design patterns, such as Induction, Know Your Audience, Sharing Wall, See Do Share, Six Minute Video, Chatflow, Bring Them Along, Provocative Question, and Sparking Forum Participation.

These 20 design patterns can be used to scaffold both novice and expert developers to develop a MOOC and propose the integration of design patterns into a simple iterative design cycle. For instance, Know Your Audience design pattern concentrates on a course design, so instructors can get to know each of their learners better. The design pattern for Know Your Audience as below:

- Pattern name: Know Your Audience
- Problem space: The open nature of MOOCs means that the barriers to sign-up are low and therefore virtually anyone can become a participant. Yet when we design a course we often have a particular type of audience in mind. With a MOOC that becomes a difficult task. How do we reconcile design with the target audience?
- Solution statement: Focus your course by using tools to find out who your learners are and what they bring to the learning journey.

Although this MOOCs design pattern mapping is an example of open online learning design patterns, they are too generic and do not focus completely on the design, development, and delivering of MOOCs, particularly computer science. Furthermore, the authors only proposed three elements of a design pattern: pattern name, problem space, and solution statement.

Methodology of Design Patterns

The methodology used for the research of design patterns is governed by such a philosophy and involved a few stages, including pattern mining, pattern writing, pattern application, and pattern evaluation (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003; Derntl & Motschnig-Pitrik, 2005; Frizell & Hubscher, 2002; Kohls & Uttecht, 2009; Persico, Pozzi, & Sarti, 2009; Retalis et al., 2006).

Kohls and Uttecht (2009) conducted pattern mining and described how to derive design patterns for interactive educational graphics from experience and analysis. However, the authors informed that the main challenge of design patterns is to find the right patterns and how to properly capture them. There are also no agreed set of standards, procedures and guidelines to define, analyze, organize and evaluate such design patterns. The authors asserted that design patterns are always work-in-progress in which they are not written down at once and forever. Every comment on the patterns introduces a new perspective and each successful application brings in a new variation or strengthens a pattern. While every failure reflects constraints on the pattern and overall, a clear understanding about its context and applicability can be achieved. Instead of focusing on pattern mining, their study also aimed to record patterns that are comprehensible, clear, and capture the expert instructional designer’s intrinsic knowledge about the actual patterns precisely, which known as pattern writing.

In contrast, Rusman, van Bruggen, Corvers, Sloep and Koper (2009) focused on the application of design patterns. The authors performed a case study in authentic educational settings, and concluded that design patterns can be applied to a new context, provided that it meets the design conditions, allowing evaluation and refinement of the pattern. Evaluation in online learning is important as it provides the feedback that helps students learn and determine how well the design patterns can improve student learning. According to Inventado and Scupelli (2015), limited evaluation of design patterns for online courses to some extent explain why design solutions do well in certain learning contexts, but failed in other contexts, for instance, different presentation platform – desktop vs. mobile, different subject content, background knowledge of the student, and student motivation.

Design patterns are captured to help other instructional designers learn from good design and reusable solutions. Thus, it is important to verify and evaluate whether design patterns could really help both novice and expert designers in their tasks. Kohls and Scheiter (2008) explained that the quality of design patterns depends on the validity and adequacy of the patterns (schema) within the contributors' mind, with the contributors in this context were referring to the expert designers. The verification and evaluation process then should only involve expert designers since they will be able to provide guidance to the pattern writer in order to refine and perfect each design pattern. In reality, design patterns are a team effort and not created by a single person. Kohls and Scheiter (2008) further added that there are a few different methods to provide evidence for the proposed design patterns: experiments, interviews, observation, and workshop.

Design patterns have been useful in other fields, ranging from architecture and software engineering to manufacturing and others. Indeed, there was some work on them in online course development, but there was a need for a comprehensive catalog that can be used and shared within the instructional designer community for designing open online courses.

Schema Theory

Expert designers construct cognitive schemas to solve recurring problems and this mental pattern is known as problem schemas (Kolfschoten et al., 2010). Expert designers use previously acquired schemas to perform particular tasks, but this is not the case with novices. Trying to understand a subject matter without prior schema is extremely difficult as the novices need to construct schemas of the concept to be learned without explanation. Thus, design patterns can be used to assist novices in acquiring design knowledge and analogical-reasoning skills from more experienced designers. Design patterns help novices remove cognitive barriers that impede the acquisition of design knowledge and domain expertise (Kolfschoten et al., 2010). Briefly, design patterns are schemas that novices can activate to better understand real things.

The seminal work of Pollock, Chandler, and Sweller (2002) discovered that an isolated-interacting elements approach had a significant effect on novice learners, rather than experienced learners. The isolated-interacting elements approach suggests to present the information in smaller steps without indicating the manner in which they interact, before providing the full interacting material (Pollock et al., 2002). For instance, the novices learn how to perform a particular task without explanation at first and when this is captured in their schema, they can easily understand the logic behind the approach. Design patterns basically do the same thing, divide a complex structure into smaller components and provide explanation on how to combine, as well as how to use these components. By pre-structuring the information, it can be absorbed in parts (involving less cognitive effort) that are meaningfully related, which facilitates schema building (Kolfschoten et al., 2010). Conversely, experts with already available and automated schemas tend to have a reverse effect as this method provides redundant information, and thus increase cognitive load.

Sweller, van Merrienboer and Paas (1998, p. 257) claimed, “They (experts) have an automated schema for this problem that tells them immediately, without conscious processing, how the problem should be solved.” Similar to patterns, problem schemas account for performance differences between experts and novices. A problem schema enables problem solvers to group problems in each category that need similar solutions (Sweller et al., 1998). Connecting design pattern concept to the schema theory can resolve problems involving in identifying patterns, as well as locating the right level of abstraction and granularity (Kohls & Uttecht, 2009). This relation can be best explained in Figure 2-3. Based on schema theory, multiple examples are required for novices to induce a schema, store the schema in long-term memory, and then transfer it when solving a new problem. Concrete examples are important as they help a novice designer to see the design in action.

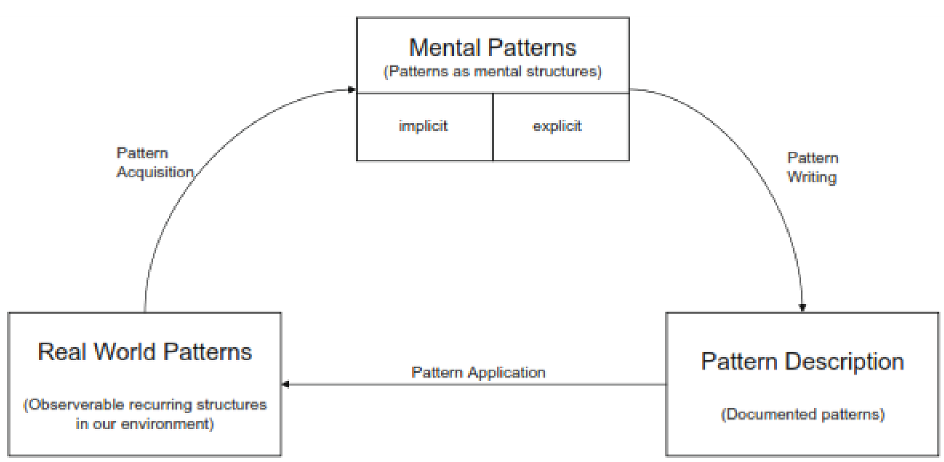

Figure 2-3. Linking schema theory to the design pattern concept (Kohls and Uttecht, 2009)

Similarly, the study by Kohls and Scheiter (2008) also made a connection between design patterns and schema theory. A schema theory explains human memory and the capability to recognize the use of schema efficiently. A schema is a mental representation within an individual's mind and is used by the brain to recognize experiences and knowledge. Design patterns are similar to the concept of schema, the documented design patterns help designers learn and assimilate or accommodate new schema. Apart from that, van der Veer and Melguizo (2002) claimed pattern languages are considered as a designer's mental model, while a schema theory provides a more comprehensive description on how patterns are acquired and represented in the designer's mind.

Kohls and Uttecht (2009) brought up a question of how our minds capture the real world patterns. Although pattern languages are considered as a mental model, it does not inform us of how the mental patterns are constructed. This is where the schema theory comes into the picture. Schema theory provides a clear explanation of how patterns are acquired and represented in the human mind. Interestingly, Kohls and Uttecht (2009) discussed two complementary processes that related to schema theory: accommodation and assimilation. Structures that are perceived in the real world are assimilated into the mental structures, and strengthened the pattern in mind. On the other hand, the mental structures will be accommodated if perceived structures do not match the pattern in mind. Experts have constructed cognitive strategies for problem solving, especially recurring ones, which is known as a problem-solving schema. Similar to the concept of patterns, a problem-solving schema enables individuals to organize problems into groups and each group requires the same generic solutions to solve problems. In addition, the invariant parts of a problem can also be captured by a problem-solving schema – the schema is being filled with the problem-specific instantiation.

Kohls and Uttecht (2009) made a good point about schema theory that describes how schemata are obtained from various examples through abstraction, and existing schemata are restructured and refined during learning. Schemata can be classified into two different types: implicit mental patterns and explicit mental patterns. Individuals have problem-solving schemata in their head with unconscious mental representations or implicitly express the context, force or the problem. This implicit knowledge can be formalized by the explicit patterns. Since the documented patterns usually refer to the real world solutions, people misunderstood that these patterns are always reliable. In reality, induction is a mental process and this suggests that pattern induction is the way people generate ideas about patterns. Thus, the documented patterns may be incorrect or incomplete – there are good design patterns that can lead to success, and how the misuse of bad design patterns can lead to problem.

To reiterate, the purpose of design patterns is to capture design knowledge, expertise, and best practices, and therefore the main purpose of documented patterns is to allow other people learn from a good design. In order to accept a pattern and recognize it as a good design, one needs to understand the problem it solves. By understanding the problem, people are not only justifying a pattern, but also become aware of the problems that current designs or practices may cause for them. Design patterns do not only provide good solutions to common problems, but also shed light on hidden problems.

Theoretical Framework

Schema theory has influenced instructional design in a variety of ways. One of them is through the notion of activating schema that has persisted in the Merrill's First Principles of Instruction – a technique for learners to impose structure on what they learn in solving problems. Many instructional models proposed that the most effective learning are those related to a real-world problem. However, most instructional practices ignore the activation of prior knowledge, application of skills, and integration of of skills into real-world activities as they focused mainly on the demonstration of skills (Merill, 2002). Merill (2002) identified five principles of instruction that have been included in a variety of design theories and models: (1) The problem-centered principle, (2) The activation principle, (3) The demonstration principle, (4) The application principle, and (5) The integration principle. Figure 2-4 shows a diagram of the Merrill's First Principles of Instruction. According to Merrill (2002, p. 44):

> (1) Learning is promoted when learners are engaged in solving real-world problems, (2) Learning is promoted when existing knowledge is activated as a foundation for new knowledge, (3) Learning is promoted when new knowledge is demonstrated to the learner, (4) Learning is promoted when new knowledge is applied by the learner, and (5) Learning is promoted when new knowledge is integrated into the learner's world.

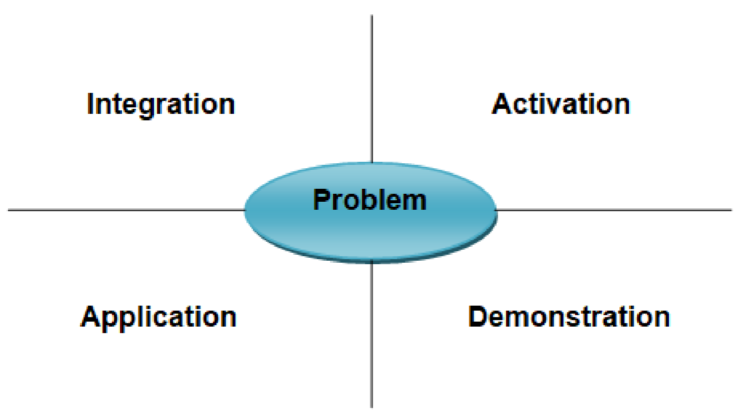

Figure 2-4. First principles of instruction (Merrill, 2002)

First principles of instruction are more into creating learning environments instead of describing how learners obtain knowledge and skill from these environments. First principles are prescriptive (design oriented) rather than descriptive (learning oriented), make it appropriate to be applied to two or more different specific situations, and also implemented in any types of system or instructional architecture. In order to demonstrate how design patterns solve design problems, first principles (Merill, 2002) were used in this study as a framework to identify patterns. The development of skills in a digital age is needed and the challenge is even greater when dealing with massive numbers as in MOOCs. The properties of the first principles are most appropriate for acquiring complex computer science skills, and providing support or structure needed to ensure conceptual and deep learning in MOOCs.

Margaryan, Bianco, and Littlejohn (2015) conducted a study to identify the extent to which the design of MOOCs reflects the fundamental principles of instruction. Margaryan et al. (2015) used first principles of instruction to determine the quality of 76 randomly selected MOOCs. They analyzed the instructional design quality of MOOCs from the first principles and from the perspective of instructional design experts. They found that the majority of MOOCs scored highly on the organization and presentation of course material, but scored poorly on most instructional design principles.

Gardner (2011a) through a systematic review of 22 contemporary instructional theories confirmed theoretical support for the first principles of instruction. First principles of instruction were abstracted from key instructional design theories and models that consist of interrelated prescriptive criteria for effective teaching and instruction. Of the 22 seven instructional theories reviewed, seven theories emphasized all five principles, 10 theories mentioned four principles, four theories highlighted three principles, and one theory emphasized two of the principles (Gardner, 2011a). Interestingly, each principle was supported by most of the instructional theories reviewed. “Demonstration was mentioned by 95% of the theories reviewed, while Application was mentioned by 100%. The principle of Problem or Task-centered was mentioned by 81% of the theories in the review, Activation was mentioned by 54%, and Integration was mentioned by 72%” (Gardner, 2011a, p. 9).

In other research, Gardner (2011b) observed how award-winning professors in higher education used the Merrill's First Principles of Instruction in real settings. This study confirmed the presence of first principles among the recognized instructors in their teaching, and linked the use of these principles to effective instruction in higher education. The study also emphasized that the effectiveness of these principles can be enhanced through positive motivational strategies and characteristics. Gardner (2011b) proposed future studies to identify the use of first principles in specific learning contexts, for instance in an online environment in higher education. It is worth noting that the existence of first principles in several different settings in higher education showed the ubiquitous nature of these principles, which suggested that they can be employed, regardless of program or practice (Gardner, 2011b).

Summary

Although there is limited research published on design patterns in education, particularly in open online learning, the existing literature builds upon the foundations of the large body of work on architecture, software engineering, manufacturing, and other design pattern research. Due to an increased need for learning at such massive scale and reduce the cost of learning support, MOOCs are likely to grow in number as they attract millions of learners. Since MOOCs are the latest trend in online learning, many higher education institutions consider offering them. Even though the use of design patterns has been shown to be an effective method to support instructional designers in designing instructional solutions, there is still a need to conduct further research on the mining, writing, and evaluation of design patterns in open online education.

CHAPTER 3
METHODOLOGY

The purpose of this study was to develop a comprehensive catalog of design patterns for open online courses by capturing, and sharing successful solutions for recurring problems in the context of Massive Open Online Courses (MOOCs). The study also sought to explore different approaches involved in developing the catalog of open online learning design patterns for computer science courses.

Research Design

As stated in Chapter 1, this study investigated the primary research questions:

1. To what extent do the design patterns exist within the Massive Open Online Courses (MOOCs) in computer science?
2. How is a catalog of design patterns for open online learning constructed?

This research was designed as a two-phase study. The first research question was answered through Phase 1. The second research question was answered through Phase 2.

Phase 1: Design Pattern Mining

The purpose of this phase was to mine design patterns of computer science MOOCs. Various techniques for pattern mining have been proposed in the literature. Retalis, Georgiakakis, and Dimitriadis (2006) suggested that design patterns can be derived from: (1) Expert instructional designers' experiences, (2) Observation of learner tasks, (3) Thorough analysis of e-learning system functionalities, (4) Literature review of pedagogical strategies, (5) Analysis of learner log files, and (6) Learn from existing published patterns. I considered all approaches suggested by the authors in the design pattern mining except the analysis of learner log files as this was unavailable to me. Table 3-1 shows the approaches to mine the design patterns of computer science

MOOCs in this study. I revisited those approaches in several phases of the complete lifecycle to collect further information that could strengthen the proposed design patterns.

Table 3-1. Design pattern mining approaches

Design Pattern Mining Strategy	Approach
1. Self-observation	Performed self-observation or introspection in defining patterns.
2. Expert interview	Interviewed instructional designers of computer science MOOCs to obtain in-depth information pertaining to the instructional designers' experiences, expertise, and knowledge in designing open online courses.
3. Artifactual study	Registered for the computer science MOOCs, went through them, analyzed the functionality, and coded the design patterns.
4. Literature review	Reviewed the literature that emphasis on the pedagogical strategies of MOOCs and also to identify common problems of open online courses.
5. Adaptation of existing published patterns	Learned from existing published design patterns in distance learning, mobile learning, online learning, human computer interaction, and other related areas.

Self-Observation

Retalis et al. (2006) proposed observation of learner tasks in eliciting design patterns for e-learning systems. Instead of observing things external to me, I chose self-observation or introspection as the first step in defining patterns. Our perspectives influence how we interpret a pattern and people may focus on different aspects because they have different experiences. It was significant to search for design patterns that could be shared and accepted by other designers. In particular, I mined for effective solutions to recurring problems that I believe were meaningful from my own experience and wrote down the patterns. However, the most challenging task in the pattern definition was the identification of a pattern and its relationship with others. I then self-evaluated the quality of each pattern and revised them when necessary.

Subjectivity statement

I earned my bachelor's degree in Computer Science with a major in Management Information System and master's degree in Computer Science with a concentration in Software Engineering, both from the University of Malaya, Malaysia. Prior to joining the faculty at the National University of Malaysia, I was a certified network engineer and my primary responsibilities were designing, installing, configuring, maintaining, and troubleshooting of network systems and technology integration functions. Working in an ICT industry for several years taught me much about the fields of software and network engineering, and has allowed me to find the best ways to leverage technology to motivate learners and positively influence their learning. My current research focus on the application of software design principles to instructional design aimed to provide instructional designers a method to create high quality designs.

When I started working on my final undergraduate project, I developed a patient information system. It was very complicated because I had to design and develop a system from scratch. The same thing happened when I was doing my master thesis entitled "An integrated tool for selecting and ranking research and development projects," a decision-support system based on object-oriented approach. It had been five years since I had finished my master's then I discovered there was a book on software design, *Design Patterns – Elements of Reusable Object-Oriented Software*. The book made me aware of the design problems I had gone through. Little did I know that this concept would lead me to my present research focus.

Through the development of open online learning design patterns, I have had the opportunity to speak with instructional designers who have designed and developed MOOCs. "The only source of knowledge is experience" – Albert Einstein. This quote made me think more about the importance of documenting design experience in open online courses. Instead of rediscovering a solution, instructional designers could reuse the experience of others in solving a problem. In their seminal work on object-oriented software design patterns, Gamma et al. (1995) said:

> The purpose of this book is to record experience in designing object-oriented software as design patterns. Each design pattern systematically names, explain, and evaluates an important and recurring design in object-oriented systems. Our goal is to capture design experience in a form that people can use effectively. (Gamma et al., 1995, p. 2)

Although Gamma et al. (1995) discussed about patterns in object-oriented software, what they said is also true for open online learning design patterns. Patterns can be constructed at a considerably higher level than source code. Thus, the solutions in this study were expressed in terms of best practices instead of objects and interfaces, but the most essential part of both types of design patterns are a solution to a known problem in a context. I found recurring patterns of instructions in many MOOC platforms. Those patterns resolve particular design problems and eventually reusable that could minimize redesign. I included patterns that have been applied more than once in different MOOC platforms. I only described design patterns that I believe successful based on my experience. Yet, this study documented only a part of what expert instructional designers might know.

Expert Interview

The purpose of the interviews was to explore the experience and expertise of instructional designers in designing, developing, and delivering computer science MOOCs for use in Phase 2 – Design Pattern Writing. Design patterns can be employed to encapsulate expert knowledge, making it easier to use and organize solutions. The expert interview took more time than self-observation because instead of mining my own experience, I conducted in-depth interviews with expert instructional designers while I observed them engaged with their MOOCs and asked them to describe their design decisions. I posed specific probe questions to assist experts in describing their tasks. This was known as Cognitive Task Analysis (CTA), a method to capture data for supporting the development of a catalog of design patterns and analytic strategies. I specifically adopted the Critical Decision Method (CDM), a semi-structured interview technique to obtain information about experts' decisions when performing their tasks (Hutchins, Pirolli, & Card, 2004).

Participants

Participants for this study were recruited from computer science MOOCs in spring and summer 2017. Potential participants were approached by sending invitations through their emails. To ensure high response rates, a personalized email was sent to each of them. The participants were required to fill out a preselection survey on their educational background and experience. The survey instrument was constructed within Qualtrics using the unmodified University of Florida template. There were 11 items in the survey questionnaire that took three minutes to complete. The questionnaire used for this survey is located in Appendix B. Participants selected in this study met the following inclusion criteria as follows:

- The participant is an instructional designer. Possible roles or titles may include professor, course developer, course manager, instructor, graduate teaching assistant, teaching assistant, instructional designer, and others.
- A participant is included if his/her primary role focuses on the design, development, and/or delivery of computer science MOOCs. This role may include full-time or part-time employment.
- The participant's instructional design experience with computer science MOOCs is formal and professional in nature.
- The participant is available for online interviews.

Four professionals responded to the survey, and, of those, two people met the inclusion criteria and were invited to participate in the study based on their background and experience. Both participants were male and they are 25-34 years old. On average, their total course enrollment ranged from 5,000 to 400,000 students. One participant held a doctoral degree, while the other had a master's degree. One participant had the title of professor and worked at a public university, also as a course instructor at a MOOC provider. Another participant had the title of course developer and worked at a MOOC provider. Following the interviews, the participants were requested to verify the initial understandings of the responses through member-checking (Johnson & Onwuegbuzie, 2004).

Interview questions

As part of the design pattern mining, a semi-structured interview protocol of 15 relevant open ended questions was developed. The questions were aimed at capturing the experience, expertise, and knowledge of instructional designers in designing, developing, and delivering computer science MOOCs. These interview questions were presented in two parts. The first part asked about the instructional perspective. For instance, one question asked the participants "Do you use any existing content from the web in your MOOC? If so, what ways do you incorporate existing web content into your MOOC design?" The second part was about the cognitive task analysis where the participants went through their MOOCs a step at a time, and I asked some questions. For instance, one question asked the participants "What design features do you use to promote the activation of prior knowledge?" The interview protocol can be found in Appendix C, along with the selected transcript of the interviews in Appendix D.

Procedures

The interviews were conducted individually via Skype, an instant messaging tool that enables video conference calls, and recorded for later transcription. The interview questions were emailed to the participants in advance so they had a chance to review the details ahead of time. During the interviews, all participants were asked the same questions in the same order.

Validity

The interviews were semi-structured, with a mixture of open ended questions to mine design patterns of computer science MOOCs. Instead of allowing the researcher to clarify questions, a semi-structured interview also enables the researcher to probe for additional information. The first draft of the research instrument was carefully reviewed by the chair of the dissertation committee and three expert peers before its administration to the study participants. Based on the experts' notes, the instrument was revised accordingly and ready for a final draft.

Validity in qualitative research can be achieved through member-checking (Johnson & Onwuegbuzie, 2004). Member-checking is usually done at the end of the interview to ensure the quality of research (Savenye & Robinson, 2004). Prior to the interviews, I asked the participants if they were willing to participate in member-checking. The interpretations of data or my initial understandings of the major points from the interviews were sent to each of these individuals to ensure that their voices were represented in the findings.

Ethical considerations

Gay, Mills, and Airasian (2009), made a statement that "Sensitivity to possible ethical issues that may arise during the study is critical to the success of the research." Prior to the Skype interviews, each participant was sent a copy of the consent form through email. The form indicated that participating in the study is voluntary, thus will not expose the participants to undue risk. I would keep the consent forms on file for three years following the completion of the research. Beginning to conduct the interviews, permission for the audio and video recording was obtained from the participants. The recordings would be destroyed after two years subsequent to the completion of this study.

At the start of each interview, the participants were explained the aim of the study, which was to collect information for cataloging design patterns through exploring their experience, expertise, and knowledge when designing open online courses. The expected length of the interview was informed to the participants, and each interview lasted between 50 and 60 minutes. To ensure any effect of subjective bias was relative, the introduction, questions, and closing remarks of the interviews were read from the pre-prepared texts so that each participant was subjected to the same situation. During the interviews, I avoided leading questions and sharing personal impressions, as well as protected sensitive information, such as name, organization, and email address.

Artifactual Study

Patterns are not only created through cognitive processes, but to some extent they can be detected from patterns in the data or systems (Retalis, et al., 2006). Alexander examined existing buildings to create most of his architectural patterns (Kohl, 2013). Many pattern authors in software engineering also used an artifactual approach to contrast and compare similar systems to develop design patterns (Kohl, 2013). In the field of open online learning, design patterns should guide the design of self-regulated learning environments, where one can be self-directed enough to learn and stay motivated, as well as make the selection or decision on valuable information in virtual settings (Lin & Cranton, 2015). The design of engaging and motivating open online learning environments is a challenging task that involves a significant amount of experience, expertise, and knowledge.

Following self-observation and expert interview, I selected the artifactual study method – analysis of the functionality of computer science MOOCs as a means to observe their behaviors for mining design patterns. Ideally, the best source for design pattern mining would have been successful and high-quality open online courses. MOOCs are primarily offered by prestigious universities and colleges, such as Harvard, MIT, and Stanford, and are taught by the same professors that teach in those prominent campuses. MOOCs provide an opportunity for instructional designers to learn best practices from others. edX, for instance, has many good instructional practices, including instructional videos with a pause button, practice exercises, online quizzes, automated grading, final projects, and discussion forums.

Given the current appearance of MOOCs, there is a clear trend that computer science is one of the most popular subjects, and dozens of computer science-related topics are available for the undergraduate and graduate levels. Most of the outstanding MOOC platforms, such as Coursera, edX, and Udacity focus on computer science courses. There are many instructional strategies designed to help learners understand the core concepts of computer science, for instance, video lectures, subtitles or transcript, lecture notes, assignments and solutions, exams and solutions, and other micro strategies, such as group discussions, stimulus response video, interactive feedback, and online forums. Udacity has recently concentrated exclusively on computer science and technology courses, providing multiple short video lectures with a series of quizzes to keep the student engaged. edX also has listed computer science courses, such as Introduction to Linux, Introduction to Java Programming, as well as Introduction to Computer Science and Programming using Python among ten most popular courses of 2016, based on total enrollments and learner ratings. Coursera provides global access to the world's best computer science education, partnering with top universities and organizations to offer courses online. Convenience sampling was used to select the MOOC platforms or providers. Table 3-2 shows the MOOC providers that were chosen in this study.

Table 3-2. MOOC providers for the design pattern mining

	MOOC Platform	URL
1.	Coursera	https://www.coursera.com
2.	edX	https://www.edx.org
3.	Udacity	https://www.udacity.com

After identifying the MOOC providers, design patterns of the most popular topics of computer science MOOCs were mined. Figure 3-1 shows the ten topics of computer science MOOCs offered by Coursera, edX, and Udacity that were selected in this study.

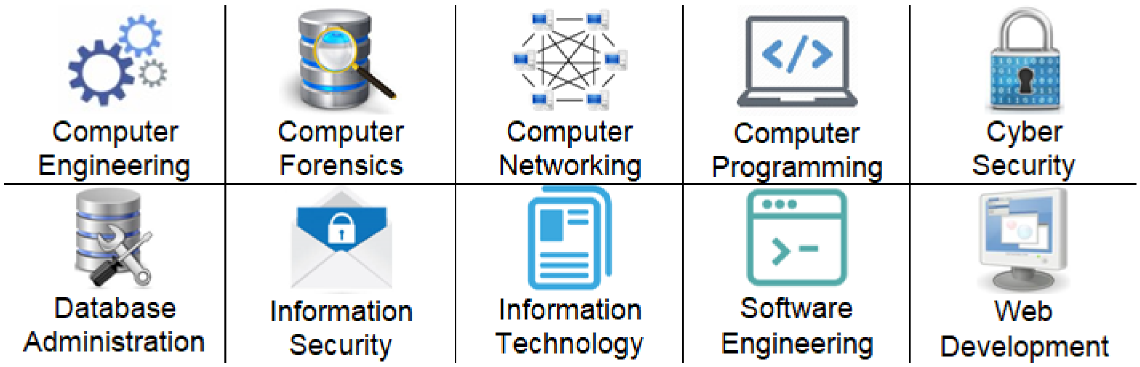

Figure 3-1. The most popular topics of computer science MOOCs

In analyzing the functionality of computer science MOOCs, I examined thoroughly the features provided by the three course providers. This approach aimed to analyze the behavior of each computer science MOOC. I compared the three computer science MOOC providers on specific features, for instance, how they assisted learners in becoming familiar and comfortable with the technologies used. I also identified what types of learner-to-learner and learner-to-content interactions were available within each MOOC. In a self-directed learning environment, it was important to identify how learners measured or tracked their personal learning progress. Further, I was interested to find out how learners receive feedback on their learning. For instance, one of the MOOCs provided automated feedback on most programming exercises and all other types of quizzes frequently. Although MOOCs are free, learners of some particular courses received personalized feedback from instructors on their project or cumulative assessment at the end of the course with substantial fees. Most MOOC providers may charge fees for assessment. The effective solutions or recurring patterns found in these MOOCs were recorded as inputs to the development of a catalog of design patterns.

Literature Review

There were a number of techniques for pattern mining that have been proposed in the literature, and one of them was the literature review. The advantages of using different pattern mining approaches that were often cited are: (1) Different approaches may produce different results even mining from the same source, (2) Assist patent authors to understand both the similarities and differences between those approaches, and (3) Help to discover challenging issues in pattern prospecting. Following self-observation, artifactual study, and expert interview, I reviewed the literature that emphasizes the pedagogical strategies of MOOCs and also identified common problems of open online courses. Since many design patterns were mined in this study, it was important to organize them. Table 3-3 shows the classification of design patterns based on the review of the literature on pedagogical strategies.

The mined design patterns were structured based on the Merrill's First Principles of Instruction because they were related to teaching and learning activities as discussed in Chapter 2. Within an educational context, theorists interpret "problem" differently. Some of them consider that a problem is a lesson plan for a learning activity that uses some form of simulation-based method, while others believe that it only means participating in real-world tasks. Merrill (2002) uses the term "problem" to incorporate a wide range of activities which learners first encounter part of the whole task activity and the task is part of the real-world problems to be solved by following instructions. The main idea of the problem-centered instruction is the components of the task are learned in isolation prior to introducing the real-world task to the learners.

Table 3-3. Design patterns organized by the design dimension adapted from Merrill's First Principles of Instruction

	Dimension	Design Pattern	Description
1.	Problem	Show Task Task Level Problem Progression	Learning is promoted when learners are engaged in solving real-world problems.
2.	Activation	Prior Knowledge Existing Experience Structure	Learning is promoted when relevant previous experience is activated.
3.	Demonstration	Demo Consistency Learner Guidance Relevant Media	Learning is promoted when the instruction demonstrates what is to be learned rather than merely telling information about what is to be learned.
4.	Application	Practice Consistency Diminishing Coaching Varied Problems	Learning is promoted when learners are required to use their new knowledge or skill to solve problems.
5.	Integration	Watch Me Reflection Creation	Learning is promoted when learners are encouraged to integrate (transfer) the new knowledge or skill into their everyday life.

Adaptation of Existing Published Patterns

Instead of the influential Alexander's architectural design patterns (1979) and Gamma's object-oriented software design patterns (1995), many published design patterns were available nowadays. I reused design expertise and exploited knowledge of patterns in other related areas as part of pattern mining. The reusable design elements were derived from expert experience and backed by theory, but could be immediately applied in new situations. Sharing and reusing good design practices could save time, and resources, as well as helping to get the right design faster. Table 3-4 shows the adaptation of existing published patterns. In general, I mined the most dominant patterns in those areas.

Table 3-4. Adaptation of design patterns from other domains

	Pattern Author	Domain	Pattern Name
1.	Al-Samarraie & Ahmad (2016)	Mobile Learning User Interface	Social activities
2.	Warburton & Mor (2015)	Open Learning	SHARING WALL FISHBOWL SPARKING FORUM PARTICIPATION
3.	Kohl (2013)	E-Learning	Prepared Example
4.	Zitter et al. (2009)	Collaborative Learning	Connect to an outside online community Introduce primary boundary objects at the start of a project
5.	Persico et al. (2009)	Collaborative Learning	Knowledge building bricks
6.	Retalis et al. (2006)	Collaborative Learning	ANNOTATION_ON_POSTED_MESSAGES
7.	McAndrew et al. (2006)	Learning Management Systems	Discussion group
8.	Derntl & Motschnig-Pitrik (2005)	Blended Learning	Generic Evaluation
9.	Eckstein (2000)	Pedagogy	Ask your neighbor Challenge Wrap-up
10.	Bergin (2000)	Computer Science Education	Early Bird Spiral Student Design Sprint

Phase 2: Design Pattern Writing

The purpose of design pattern writing was two-fold: (1) To provide a standard template for instructional designers to express their design expertise to other instructional design professionals, and (2) To describe and organize design patterns for open online learning using a standard template. Design patterns are written at a high level of abstraction in which the problems are easy to recognize instead of being written in a specific way. The underlying idea behind design patterns is to guide rather than prescribe, a feature that makes them potentially a useful tool for designing effective learning courses (Rohse & Anderson, 2006).

Design patterns are intentionally incomplete as they share expertise, but do not limit creativity (Gamma et al., 1995). For instance, an instructional designer that encounters an unfamiliar topic can still recognize the problem description as stated in the design pattern, but, the specific activity will be influenced by their expertise, experience, and knowledge. Implementing design pattern requires the instructional designer to engage with the pattern and interpret the pedagogic descriptions to their own needs. As the instructional designer finds potential ideas and new directions, the nature of their topic changes, so do the subsequent activities. Further information and examples to support the pattern's use, including references to related work provide an instructional designer the opportunity to create activities for the topic at hand.

Besides providing facts, design patterns also describe the design knowledge in a more descriptive way. I focused on the practicality of design patterns since the goal of design patterns was the description of reusable solutions to recurring problems. During Phase 2, design patterns were described and organized in a standard format. To reiterate, design patterns are a tool for documenting and reusing previous solutions. A template to describe and organize design patterns for open online learning was modified from the Gamma et al. (1995) and Alexander (1979) pattern structures. In order to reuse design patterns, it is important to effectively document them using a consistent format that helps novice designers in scanning and selecting patterns. Each design pattern was named, explained, and described systematically. Figure 3-2, Figure 3-3, and Figure 3-4 illustrate a template to describe open online learning design patterns and the explanation for each section. There are eight sections in the template of design patterns: Pattern Name, Also Known As, Problem, Context, Solution, Related Patterns, Examples, and References.

Pattern Name

The pattern name provides a shared vocabulary for both the pattern writer and the content expert that enables unambiguous communication (Kohls & Uttecht, 2009). Hence, it is important to give a descriptive and unique name for identifying and referring the pattern, with the purpose to describe a design problem, its solutions and also consequences. According to Gamma et al. (1995), naming a pattern immediately increases design vocabulary. Likewise, Derntl and Motschnig-Pitrik (2005) pointed out that the pattern name is a meaningful descriptor for the pattern to convey its essence. Kolfschoten et al. (2010) suggested that patterns should have catchy names to describe and remember them.

Also Known As

It refers to act of giving other names for the pattern, if necessary.

Problem

This section provides a brief description of the design problem at hand. Gamma et al. (1995) described problems as motivations, the scenarios that help us to better understand the abstract description of the pattern and then illustrate how the elements of the pattern could solve the problem. In contrast, Alexander (1979) emphasized on the forces, such as issues or concerns that are acting on the

Figure 3-2. Design pattern template 1

problem, and the rational for selecting a particular solution.

Context

This section explains a context for the problem in order to avoid an over generalized solution (Rohse & Anderson, 2006). Also, a context can be defined as a description of the indicators/factors that influence the use and implementation of the solution (Zitter et al., 2009). Describing the context is crucial as it helps to communicate the nature of the problem and its solution. Designers can adapt the invariant aspects captured by the pattern to a variety of design problems within a similar context (Bianco, Robinson, Metcher, & Hendy, 2011). Gamma et al. (1995) referred to this as applicability, provides situations for which the pattern could be suitable. Further, they emphasize that it is important to give examples of poor designs, which the pattern can solve, and an explanation of the sources of the problem.

Solution

This section refers to a description of the solution proposed by this pattern that addresses the problem and context, including the best practices that show how the problem can be solved (Zitter et al., 2009). However, Gamma et al. (1995) and Derntl and Motschnig-Pitrik (2005) described solutions as intents, a brief statement pertaining to the scenario or situation the pattern addresses.

Related Patterns

It refers to a list of closely related patterns as references that support the solution.

Examples

This section gives examples of putting the pattern into practice, especially pictures to illustrate the use of pattern in actual courses and to clarify the invariant aspects of different cases (Bokhorst, et al., 2014). Gamma et al. (1995) suggested to provide at least two concrete examples found in different contexts. Thus, each example helps the pattern reader to understand the core and meaning of a pattern. Similarly, Kohls and Uttecht (2009) considered this section as indispensable since examples are the most powerful medium to convey the message of a pattern and provide an implicit way of giving evidence for the

Figure 3-3. Design pattern template 2

pattern. According to schema theory, a learner requires multiple examples to induce a schema.

References

The supporting research presents a list of references to literature or related work in order to support the use of pattern.

Figure 3-4. Design pattern template 3

The design pattern template provides a standard structure to the information, making design patterns easier to learn, share, and use. In particular, each pattern allows designers to express their design expertise into pre-defined categories for the purpose of stimulating abstraction. The design patterns then should be presented in the same narrative structure and ordered hierarchically, that contained those eight sections and elements. However, this design pattern could only make sense when it is used with the other related design patterns. In other words, each design pattern was not isolated, but it was interrelated to other design patterns in the catalog.

Implementing design patterns not only requires the designer to engage with the pattern, but also to interpret the narratives consisting of pedagogical descriptions and pictures to meet their needs. Examples and references to related work give the instructional designer ideas to design their courses. Design patterns are an effective way to express design expertise and make explicit the mental patterns that exist within expert designers in solving recurring problems. Ideally, the instructional design patterns should focus on the problems of the end users, rather than the problems of the designers (Frizell & Hubscher, 2002). The learner participating in the learning experience is considered the end user.

Data Analysis

Following mining, the patterns were further examined through content analysis. Considering the purpose of this study, the qualitative content analysis was selected as an appropriate analysis approach to review and interpret patterns. Content analysis is a method for providing new insights, knowledge, representation of facts, and a practical guide to action, as well as for making valid inferences from data to their contexts (Krippendorff, 2012). Four main stages were involved in analyzing the data as proposed by Bengtsson (2016): (1) Decontextualization, (2) Recontextualization, (3) Categorization, and (4) Compilation. To ensure the trustworthiness of the analysis, each stage was visited several times during data analysis. Figure 3-5 illustrates the process of the qualitative content analysis from data collection to presentation of the result. In qualitative content analysis, data are presented in the forms of themes and words (Bengtsson, 2016), enabling the researcher to interpret results and draw conclusions. The results of these analyses are detailed in Chapter 4.

I read through the transcribed interviews repeatedly to familiarize myself with the data and to get a general idea of the whole text. The transcripts were broken down into smaller meaning units and resulted in 25 relevant units considered for analysis. I labeled each identified meaning unit with a code that can be recognized in relation to the context. Berg (2001) recognized this procedure as an open coding process. In the analysis process, codes basically facilitate the identification of concepts that can be assembled into groups. To ensure the reliability of the analysis, I used a coding list to reduce a cognitive change throughout the analysis process. Codes were generated inductively, which the list was created during the analysis process and changed as the study progresses.

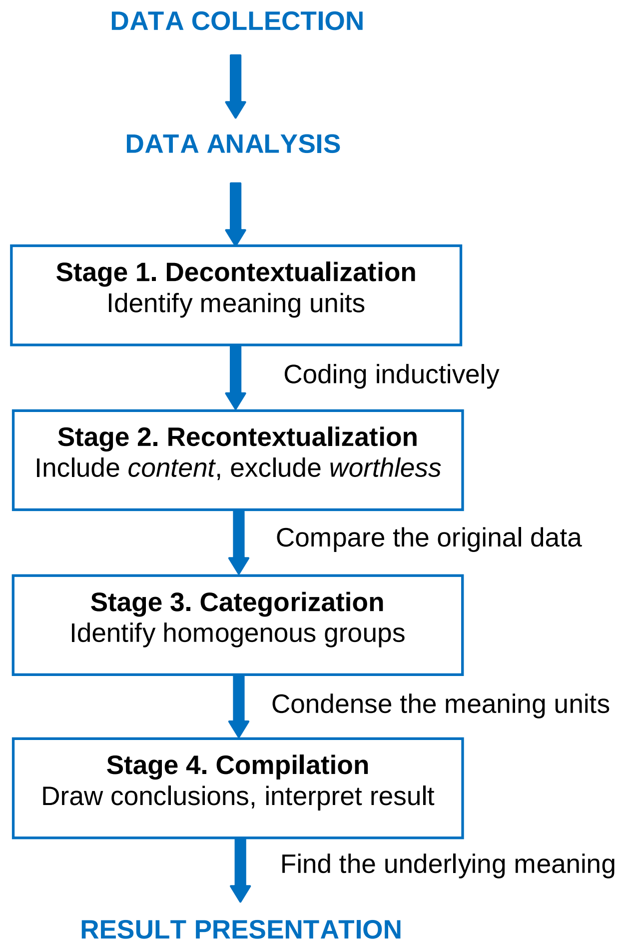

Figure 3-5. Qualitative content analysis process

I used NVivo11 to facilitate and speed up the coding process by finding codes and grouping data into their own categories. After the meaning units have been identified, I reviewed if all aspects of the content have been covered in relation to the purpose of the study. I read again the original transcripts together with the list of meaning units. I made sure that the important information was included in the analysis while the unimportant ones were excluded. Meaning units were condensed prior to creating categories, which insignificant words were removed without losing the content. The coded data were basically divided based on the interview questions. Categories and themes were then identified in the categorization process. According to

Krippendorff (2004), the data should not be in between categories and themes or fit into more than one group. Theme refers to the underlying meaning of the texts in order to answer a research question (Bengtsson, 2016).

Summary

The use of design patterns has evolved to solve problems often encountered in architecture, prominently in software engineering, and recently in the instructional design communities. Design patterns in this study consisted of reusable solutions generalized from a number of successful design cases and best practices. This study proposed a template to the instructional design community on how to effectively document and communicate design patterns in an open online learning context. Instructional designers can use this template to express their design expertise to other instructional design professionals and also make use of design patterns in practice.

CHAPTER 4
RESULTS

The purpose of this research study was to develop a catalog of open online learning design patterns for computer science courses, a template for documenting and reusing successful design solutions. The study also sought to explore different approaches that contribute to the rich description of the catalog of design patterns. The research questions of this study were:

1. To what extent do the design patterns exist within the Massive Open Online Courses in computer science?
2. How is a catalog of design patterns for open online learning constructed?

During in-depth interviews, study participants described their experiences and perceptions in designing, developing, and delivering computer science MOOCs. The research findings were also based on the analysis of the following data sources: self-observation, functionality of computer science MOOCs, literature on pedagogical strategies, and existing published patterns in other related areas.

Background

The interview participants of this study were comprised of two instructional designers from the leading MOOC providers. They aged between 25 to 34 years old and both were male. One participant holds a Doctor of Philosophy (PhD) and one participant holds a Master's degree.

Study Findings

This chapter consists of two parts. The first part is the study findings from expert interviews, and the second part is the overall findings in the form of the catalog of open online learning design patterns for computer science courses.

Use of Online Affordances

In order to understand the interactivity, communication, and collaboration within MOOCs, I asked participants questions about what types of interactions are available in their MOOCs and how they facilitate those interactions. One participant explained the learner-to-learner interaction in his MOOCs:

> Our class is very active. It's the main place where students interact with each other. We use a peer feedback system. It's called Peer Feedback. Every week, we assign students three or four assignments from their peers, just to review, grade on a rubric, but we didn't use it for any actual grading. We just used a grade to put them in a position of approaching things from that angle. So that is the main thing for learner-to-learner interaction. So I think that's mostly the peer feedback, as well as the forums. We also post exemplary assignments for a chance at peer feedback, so students kind of comparing what they did to the best in the class.

Another participant mentioned that besides discussion forums for communication, learners can even connect to one another in-person through Udacity Connect. Learner-to-learner interaction is the most common type of communication that exists in open online education (Gameel, 2017). This interaction refers to the exchange of information and ideas among learners geographically dispersed, either through asynchronous (discussion forums) or synchronous communication (chats). Table 4-1 and Table 4-2 illustrate the content analysis process from condensed data to category.

Table 4-1. Transcribed interview with a participant regarding the interaction among learners part 1

Condensed Meaning Unit	Code	Category
We use a peer feedback system named Peer Feedback. Every week, we assign students three or four assignments from their peers, for them to review, grade based on a rubric, but we did not use it for	Interactivity, communication, and collaboration	Learner-to-learner interaction

Table 4-2. Transcribed interview with a participant regarding the interaction among learners part 2

Condensed Meaning Unit	Code	Category
any actual grading. We also post exemplary assignments at Peer Feedback, so students can compare what they did to the best in the class. Instead of the peer feedback, we also have forums for learner-to-learner interaction.	Interactivity, communication, and collaboration	Learner-to-learner interaction

Prior work found that many learners struggle with motivation and self-regulated learning in MOOCs. Hence, I asked participants how learners measure or track their personal learning progress. One participant said, "... we display their progress on the site. Students demonstrate skills by building projects." Another participant described two ways of tracking personal learning progress:

> One is progress through the material, just kind of how far they are. And one is how well they're doing at understanding it. In terms of how far they are, you've got a screen visualize basically a course, let's say you are 35 percent through this course. And last time you were here, you were on this lesson. And you're halfway through this lesson. So they visualize that kind of progress in that way. Also, we create them quizzes so they know how well they're actually understanding and demonstrating their understanding of the material. They also have tests and projects usual kind of trappings.

For learner-to-content interaction, it is mostly based around online recorded videos of short lectures. As one mentioned, "so we give them course content made of 15, 20 lessons, and they will watch these lessons." Another participant also explained that they used video for quiz introductions, quiz solutions, tutorials, intros, outros, and explanations, and text for supporting information. While interactive programming quizzes are used for student self-assessment. The content analysis process from condensed data to category as in Table 4-3.

Table 4-3. Transcribed interviews with participants regarding the interaction of learners with contents

Condensed Meaning Unit	Code	Category
First is progress through the material of how far they are. Second is how well they understand it. In terms of how far they are, you have got a screen visualize a course, let's say you are 35 percent through this course and last time you were here, you were on this lesson, and you are halfway through this lesson. So they visualize that kind of progress. Also, we create them quizzes so they know how well they understand the material, and demonstrate their understanding. They also have tests and projects.	Track personal learning progress	Learner-to-content interaction
Our three kinds of video are one week home head chats, which is I am just standing in a studio, it is white behind, I am talking directly to the camera. We filmed in my class, at my house, and at our office. We also do what we call tablet recording, which is basically I will have a PowerPoint presentation. I will point or motion to things, and they will see my hands interact with the content. That is usually for diagrams.	Media and technologies	Learner-to-content interaction

Learners usually received automated feedback on most programming exercises and all other types of quizzes frequently. Learners who were enrolled in the Nanodegree received personalized feedback from a grader on their project or cumulative assessment at the end of the course. Due to open access and massive enrollments, instructors could interact with learners in a way that does not require them to provide individual messages to each learner, such as a broadcast method.

Although little learner-to-instructor interaction happens in MOOCs, one participant explained that they interact with learners through free online collaboration platforms that have been integrated into the MOOC.

> So the two main ways are our forum and Slack. The place we mostly direct things are on the forum. We have a team of TAs, who are available to answer questions. Their main responsibility is actually creating assignments, but they're also available to answer questions on Piazza. And I do as well. It's all Piazza formats that we use. And so we have that as the main tool. I also have three times weekly office hours. So we also communicate via Slack, just because it's easier on me via chat. And so we have those three times a week. Realistically, students learn pretty quickly that if they message me on Slack, I'm probably there, just because I'm always kind of at my computer. So the office hours being scheduled kind of disappear pretty quickly because I'm usually there.

Piazza is a free Q&A web service that helps learners interact with professors, teaching assistants, and peers. Piazza is designed with a wiki and forum style formats that can be integrated into most Learning Management Systems (LMSs). Some key features of Piazza including anonymous posting to promote learner participation, highlighting questions and posts that require immediate action, and creating online polls. While Slack is a collaboration tool with basic features such as messaging, video calling, file sharing, and archiving. Founded by Steward Butterfield in 2013, Slack provides many Internet Relay Chat (IRC) features, particularly persistent chat rooms organized by discussion topic. Table 4-4 illustrates the content analysis process from condensed data to category.

Table 4-4. Transcribed interview with a participant regarding the interaction between learner and instructor

Condensed Meaning Unit	Code	Category
The two main ways are forum and Slack. The place we mostly direct things are on the forum. We have a team of TAs, who are available to answer questions. Their main responsibility is actually creating assignments, but they are also available to answer questions on Piazza. And I do as well. We also communicate via Slack, just because it is easier on me via chat. Realistically, students learn pretty quickly that if they message me on Slack as I am usually there.	Interactivity, communication, and collaboration	Learner-to-instructor interaction

Content and Course Material

MOOC can be effective at communicating difficult material and abstract concepts of computer science. Hence, it is important to evaluate the courses since well-designed MOOCs could be as effective for learning as traditional classes. I asked participants to describe the process of ensuring the effectiveness of MOOCs before they are released. One participant explained the process:

> We used to have a process by which we would do beta testers, things like that. We do beta test, we just do it very early on. We discovered it’s basically once you filmed, you’re very unlikely to go back and re-film because the cost of re-filming is so high. If you’re using that improvement to justify the cost. So instead we feel more into peer reviewing scripts and reviewing things in advance before they’re ever filmed. So we never really reviewed them after it is produced. We will work on a review with my crew as we go along. Our process is all about partnering a professor with instructional designers who experts in doing online courses. And so they provide that, it’s ongoing expertise as opposed to waiting to film it all and

seeing at the end that oh, sorry, this is awful, go back and do everything again.

Beta testing or pre-launch testing is an important function of quality control and a critical step before a software product is released (Sekhon & Hartley, 2014). Beta testing then can be used as one of the MOOC quality assurance approaches to help uncover content errors, level of user involvement, software bugs, and usability (Sekhon & Hartley, 2014). Generally, learners will participate in testing of the MOOC materials before they go live to improve the quality of courses by catching and pointing out mistakes in video lectures and quizzes. Professors will also peer review the materials to assure the quality of the content. The content analysis process from condensed data to category as in Table 4-5.

Table 4-5. Transcribed interview with a participant regarding course effectiveness

Condensed Meaning Unit	Code	Category
We used to have a beta test and we did it very early on. We discovered it is basically once you filmed, you are very unlikely to go back and re-film because the cost of re-filming is so high. Instead, we feel more into peer reviewing scripts and reviewing things in advance before they are filmed. So we never really reviewed them after it is produced. We will work on a review with my crew as we go along. Our process is all about partnering a professor with instructional designers who experts in doing online courses. It is ongoing expertise as opposed to waiting to film it all and seeing at the end, go back and do everything again.	Quality control	MOOC testing

I also asked the participants a question on how they obtain learner feedback during and after the course. One participant explained two main ways to obtain learner feedback:

> We have four surveys that we take during the course of the semester. It's a starter course, quarter course, mid-course, and end of course survey. That we give in the weeks. So our semester is 17 weeks. We give the surveys at week 1, 5, 9, and 17. We used to give one at 13, but then we just kind of realized that at week 13, we're not gaining any real new information. At the end of course survey, we ask different questions so they're a little bit more substantive. So we dropped the three quarters course survey. So we've got those. On those surveys, they answer those questions like how would you rate this class against others from the strengths and weaknesses? As well as open ended questions, you know that are meant to let a student improve mid-semester.

He also indicated that they provided a folder called Feedback Box that allows learners to post any feedback to the instructors.

> I like that method because then we get to see other students' perspective. So a couple times in a couple classes, we've had instances where students will email and say hey, I think X could use improvement. And the professor tried to improve X, and they found out oh all the other students liked it better the old way, it's just that the one student decided to say something. Why was it changed? And so when they post on Piazza, we get an email, we can hear from other students, whether they support it, don't like it, or not.

Table 4-6 and Table 4-7 illustrate the content analysis process from condensed data to category.

Table 4-6. Transcribed interviews with participants regarding learner evaluation part 1

Condensed Meaning Unit	Code	Category
We have a folder called Feedback Box, where any time you have any feedback for us, please just post there. I like that method because we get to see other students' perspective. When they post on Piazza, we get an email, we can hear from other students whether, they support it, do not like it, or not.	Learner feedback	MOOC evaluation

Table 4-7. Transcribed interviews with participants regarding learner evaluation part 2

Condensed Meaning Unit	Code	Category
We have four surveys for each course of the semester. It is a starter course, quarter course, mid-course, and end of course survey. Our semester is 17 weeks. We give the surveys at week 1, 5, 9, and 17. We used to give one at 13, but then we just kind of realized that at week 13, we are not gaining any real new information. In the end of course survey, we ask different questions so they are a little bit more substantive. So we dropped the three quarters course survey. On those surveys, they answer those questions like how would you rate this class against others from the strengths and weaknesses? As well as open ended questions, you know that are meant to let a student improve mid-semester.	Learner survey	MOOC evaluation

Instructional Strategy and Learning Outcomes

Learning outcomes in a MOOC platform may not be similar to those in traditional or regular online education. Understanding the factors influencing learning outcomes, particularly learning activities and teaching context are significant as they are important steps towards designing effective open online courses. I asked participants, which approaches to instruction have proven to be the most effective in the implementation of the MOOCs. One participant mentioned about interactive and constant activities for learners. He also pointed out, “Engaging presentation of the content, less PowerPoint and more friend-sitting-next-to-you-explaining-things. I used to teach science. Hands on is the best, so I made my classes as hands on as possible." Another participant explained:

> I would say that the most important thing is actually a match between content and instruction. So it seems in instances where professors try to teach, I've heard that X works best, but X doesn't work best for their content. And so, for example, in my HCI class, it's very video heavy. We focus on those video lessons. We go on with this. In my Educational Technology class, there's basically no video whatsoever. It's all project based. It's all open ended. It's based on more of a mentorship model, where you work closely with a particular TA. And so I think the number one point is, the most important thing is the match the instruction to the learning goals and to the assessments that are going to be used. I guess matching assessments to learning goals and their learning goals to instruction style.

He added that "rapid feedback is probably the most effective thing to leverage as where we can," however:

> We can't really do it in my HCI class because it's all open ended. But my undergrad class, I have rapid feedback, the instantaneous assessment of where you are, when you can move on. I think it's the most effective thing we can do when we can do it. I have seen professors try to do that in material where it doesn't work. And then I think I lost a lot of effectiveness. It's the kind of thing that you know, you need to find a way to do that, if it works for your material. Just do that. Other than that, a lot of it is fostering student community. Fostering student activity, responsiveness, just because students feel that they're actually in touch with people, not just a playlist with quizzes next to it.

Most MOOCs provide an automated grading method for quizzes, such as true/false, multiple choice, and short answer sets. To investigate the types of assessment used for grading, I asked participants a question about how they assess the learning outcomes or results of those that participate in the MOOC:

> Technically the tests are automated, so the tests are all multiple choice. It's 100, it's basically 100 true or false questions. So that's basically how it boils down. And that actually gets us an objective and outlet variable. From the course. Other than that, it's the assignments. The assignments don't change that much semester to semester, but because they are human created, the output there is not quite as reliable as you know, the objective true or false. So we also use those.

Another participant said, “We watch the forums, talk to students and watch engagement numbers... number of learners progressing into the course.” He further added, “... we measure the number of students who get jobs after completing the Nanodegree.” The content analysis process from condensed data to category as in Table 4-8 and Table 4-9.

Table 4-8. Transcribed interviews with participants regarding instructional strategy and learning outcomes part 1

Condensed Meaning Unit	Code	Category
The most important thing is actually a match between content and instruction. So it seems in instances where professors try to teach, I have heard that X works best, but X does not work best for their content. For example, in my HCI class, it is very video heavy. In my Educational Technology class, there is basically no video whatsoever. It is all project based, it is all open ended. It is based on more of a mentorship model, where you work closely with a particular TA. So I think the most important thing is to match the instruction to the learning goals and to the assessments that are going to be used.	Effective instruction	Practice consistency
Technically the tests are automated, so the tests are all multiple choice. It is basically 100 true or false questions. And that actually gets us an objective and outlet variable from the course. Other than that, it is the assignments. The assignments do not change that much semester to semester, but because they are human created, the output there is not quite as reliable as the objective true or false.	Automated grading	Learning outcomes

Table 4-9. Transcribed interviews with participants regarding instructional strategy and learning outcomes part 2

Condensed Meaning Unit	Code	Category
The rapid feedback is probably the most effective thing. We cannot really do it in my HCI class because it is all open ended. But my other class, I have rapid feedback, the instantaneous assessment of where you are, when you can move on. Other than that, a lot of it is fostering student community. Fostering student activity, responsiveness, just because students feel that they are actually in touch with people, not just a playlist with quizzes next to it.	Rapid feedback	Learning outcomes

Knowledge Activation

Activation involves more than just enabling learners to recall prior knowledge or provide relevant experience. To stimulate the development of the schemes and mental models, learning activities should be designed to help learners integrate the new knowledge and skill into new experience. Hence, I asked participants what design features do they use to promote the activation of prior knowledge.

> So the main thing we do is basically... it's an old quote, from, I don't know what it's from, but it's about giving a good speech. And it's telling them what you're going to tell them. Tell them, and then tell them what you told them. So it's basically today, I'm going to talk to you about X, Y, and Z. Talk about X, Y, and Z. And then at the end you'd say, today we talked about X, Y, and Z, and remember we said this, and go look at this. We designed the entire course that way. So unit one is like the introduction part of the entire course. We say in this entire course, we're going to talk about all of this. Unit five is, in this entire course, we talked about this. Within each unit, we do that too.

He also explained that the first lesson in each unit is the introduction to the unit:

> Here's what we're going to talk about in this unit. And within each lesson, the first video, here's what we'll talk about in this lesson, here's what we talked about this... you know, talked about this lesson. We probably use this a lot to connect to other areas of the course material, as well as things that students might have elsewhere. So we'll say in the introduction to the lesson you know, in this lesson we're going to talk about representations. What you'll find is that these heavily leverage the limitations of human psychology, we talked about last lesson. And notice also that what we talked about in this lesson, you're going to see again in the next lesson. So it kind of half set aside places where we're talking about the content instead of teaching the content. We also have we have various checkpoints that basically say try and see how this applies in the real world, you know, so we try to have them connect it out to something beyond the course. And our assignments often do that too. Basically say, think of an interface that you use in everyday life, analyze it from the perspective of cognition. And so it kind of connects what they know or did before starting the course.

Another participant mentioned, "... practice and students constantly work with sites." The content analysis process from condensed data to category as in Table 4-10 and Table 4-11.

Table 4-10. Transcribed interviews with participants regarding instructional strategy part 1

Condensed Meaning Unit	Code	Category
The main thing is about giving a good speech. Tell them what you are going to tell them. So it is basically today, I am going to talk to you about X, Y, and Z. Talk about X, Y, and Z. Then at the end you would say, today we talked about X, Y, and Z, and remember we said this, and go look at this. We designed the entire course that way. So unit one is like the introduction part of the entire course. We say in this entire course, we are going to talk about all of this. Unit five is, in this entire course, we talked about this. Within each unit, we do that too.	Approach to instruction	Prior knowledge

Table 4-11. Transcribed interviews with participants regarding instructional strategy part 2

Condensed Meaning Unit	Code	Category
The first lesson in each unit is the introduction to this unit. Here is what we are going to talk about in this unit. Within each lesson, the first video, here is what we will talk about in this lesson, here is what we talked about this, talked about this lesson. We probably use this a lot to connect to other areas of the course material, as well as things that students might have elsewhere. So we will say in the introduction to the lesson, in this lesson we are going to talk about representations. What you will find is that these heavily leverage the limitations of human psychology, we talked about last lesson. And notice also that what we talked about in this lesson, you are going to see again in the next lesson. So it kind of half set aside places where we are talking about the content instead of teaching the content. We also have various checkpoints that basically say try and see how this applies in the real world, so we try to have them connect it out to something beyond the course. And our assignments often do that too. Basically say, think of an interface that you use in everyday life, analyze it from the perspective of cognition. And so it kind of connects what they know or did before starting the course.	Approach to instruction	Structure

Further, I asked participants about what knowledge, skills, and dispositions are needed for the successful completion of the MOOC. One participant mentioned about basic web development skills, good attitude, and willingness to try things. Another participant described:

> I'd say that generally when they're entering a course, they need very little prior knowledge. We can't require hard computer science knowledge because there are people who aren't taking computer science courses. Just kind of interesting. I'd say that they need to have a disposition towards a curious mindset.

By giving an example of his Human Computer Interaction (HCI) course, he indicated:

> Then to complete the class with everything that you need to development is a kind of two general assessments of skills. You need to know the ability to analyzing a user interface and reassign from the perspectives of principals of teach. And that, actually, I guess that's the overall skill. That means different things, so that means understanding how known theories and ideas apply different places. And it means understanding how to go through a process of designing something, testing with the user, looking at the results, revising it. So both kinds of the mechanics of being able to do it, and then the workflow of doing it, basically doing it well.

Table 4-12 and Table 4-13 illustrate the content analysis process from condensed data to category.

Table 4-12. Transcribed interviews with participants regarding course completion part 1

Condensed Meaning Unit	Code	Category
I would say that generally when they are entering a course, they need very little prior knowledge. We cannot require hard computer science knowledge because there are people who are not taking computer science courses. I would say that they need to have a disposition towards a curious mindset.	Successful course completion	Prior knowledge

Table 4-13. Transcribed interviews with participants regarding course completion part 2

Condensed Meaning Unit	Code	Category
Then to complete the class with everything that you need to development is a kind of two general assessments of skills. You need to know the ability to analyzing a user interface and reassign from the perspectives of principals of teach. I guess that is the overall skill. So that means understanding how known theories and ideas apply different places. And it means understanding how to go through a process of designing something, testing with the user, looking at the results, revising it.	Successful course completion	New experience

Given that MOOCs are becoming increasingly popular worldwide, factors influencing learners' motivation should be further explored.

> So the only ones who are taking the course are the ones who are interested in the course. There aren't students who take it because they need that credit. This is a link to a student run review set, where students have reviews on one of the courses in the program. And it's publicly available, so you can see what everyone is saying. Based on that, I would speculate that the reasons why students take this course. One is that they've taken my earlier courses and they've liked them. And they just want to take another one with me. One is that the topic is very applicable, no matter what you're going into. So it's very accessible, since there's no computer science required for it. It's also weighted as one of the easiest, but probably the bottom 30 percent in terms of difficulty. And so I think there are students who take it because they want to finish and they will take the easy class in every session. And then the other is, all our students do a report that they find this kind of development to whatever they do professionally. So working in computer science, anyone could benefit from this perspective. So I think those are the four main reasons I see.

Another participant believed that the reasons learners participated in the MOOC were to improve their web development skills and build websites faster. The content analysis process from condensed data to category as in Table 4-14.

Table 4-14. Transcribed interviews with participants regarding motivation

Condensed Meaning Unit	Code	Category
So the only ones who are taking the course are the ones who are interested in the course. This is a link to a student run review set, where students have reviews on one of the courses in the program. And it is publicly available, so you can see what everyone is saying. Based on that, I would speculate that the reasons why students take this course. One is that they have taken my earlier courses and they have liked them. And they just want to take another one with me. One is that the topic is very applicable, no matter what you are going into. So it is very accessible, since there is no computer science required for it. It is also weighted as one of the easiest, but probably the bottom 30 percent in terms of difficulty. So I think there are students who take it because they want to finish and they will take the easy class in every session. And then the other is, all our students do a report that they find this kind of development to whatever they do professionally. Working in computer science, anyone could benefit from this perspective.	Personal interest	Prior knowledge

Transfer of Learning

Learning transfer refers to the learner's ability to successfully apply the previously acquired knowledge and skills to new contexts. Course design features are among the important factors for promoting transfer to real-world situations. One participant explained,

> We have lots of checkpoints and our assignments are based on that. The projects are both things that students are encouraged to take or that they care about in the real world. Mentally encourage students that you know, to basically say if you have a UI design thing you have to do for work, feel free to do it for this class. We like that, because then you get feedback from the creator, you get feedback from your peers, and you also get to use it for work. So we promote a lot of those connections out to students to use in the real world. And this class, it's very easy, just because it's human interaction, everyone's interacting with computers all the time, especially if you're taking an online course, so of course you are. So in this class, it's pretty easy to do that.

The emerging factors in MOOC design were further explored by a probing question to understand how they provide adequate practice for learners to apply new knowledge or skills for a variety of problems. One participant emphasized the value of learning activities.

> I think those mostly come through the assignments right now. I don't know if I'd quite call it adequate for mastering material as adequate for demonstrating that you have the capacity to master the material if that makes sense.

Another participant indicated "... the entire course is basically a series of challenges where students are given real-websites and are asked them to debug them." Table 4-15 illustrates the content analysis process from condensed data to category.

Table 4-15. Transcribed interviews with participants related to transfer of learning

Condensed Meaning Unit	Code	Category
We have lots of checkpoints and our assignments are based on that. The projects are both things that students are encouraged to take or that they care about in the real world. Mentally encourage students that you know, to basically say if you have a UI design thing you have to do for work, feel free to do it for this class. We like that, because then you get feedback from the creator, you get feedback from your peers, and you also get to use it for work. So we promote a lot of those connections out to students to use in the real world. And this class it is very easy, just because it is human interaction, everyone is interacting with computers all the time.	Real-world problem	Creation
I think those mostly come through the assignments right now. I do not know if I would quite call it adequate for mastering material as adequate for demonstrating that you have the capacity to master the material if that makes sense.	Mastering material	Demonstrate new skill or knowledge

The first research question was answered through the design pattern mining. To reiterate, the design pattern mining involved five main approaches, including expert interviews. Interview participants contributed differing amounts of information to the five themes that comprised the narrative. One participant talked at length on two or three themes, and another participant made nearly equal contributions across all five themes. Hence, both participants' views and voices were represented in this study. The second research question was answered through the catalog of open online learning design patterns for computer science courses.

Design Patterns as the link between Theory and Practice

The goal of this section was to structure the information presented in the catalog of design patterns in a way that assists instructional designers in organizing knowledge by principles. Since there were many instructional design patterns that have been identified in this study, it was important to organize them. Figure 4-1 provides a theoretical framework for this study and the classification of design patterns. This figure classifies design patterns so they can be referred to families of related patterns. The classification helps designers learn the design patterns in the catalog faster, as well as it can direct efforts to find new design patterns, if any.

Blue oval represents the dimension or category of patterns, while the white oval represents the design patterns. Taken together, there are five dimensions of patterns with 15 design patterns for open online learning. The catalog of design patterns is a set of pattern that has a relatively low level of structure and classification. A pattern language then is the coherent and interrelated design patterns that can be used to solve problems in a specific domain (Bokhorst et al., 2014). All dimensions and design patterns were adapted from Merrill's First Principles of Instruction (2012) and these principles were a fundamental principle for the dimensions of patterns and design patterns.

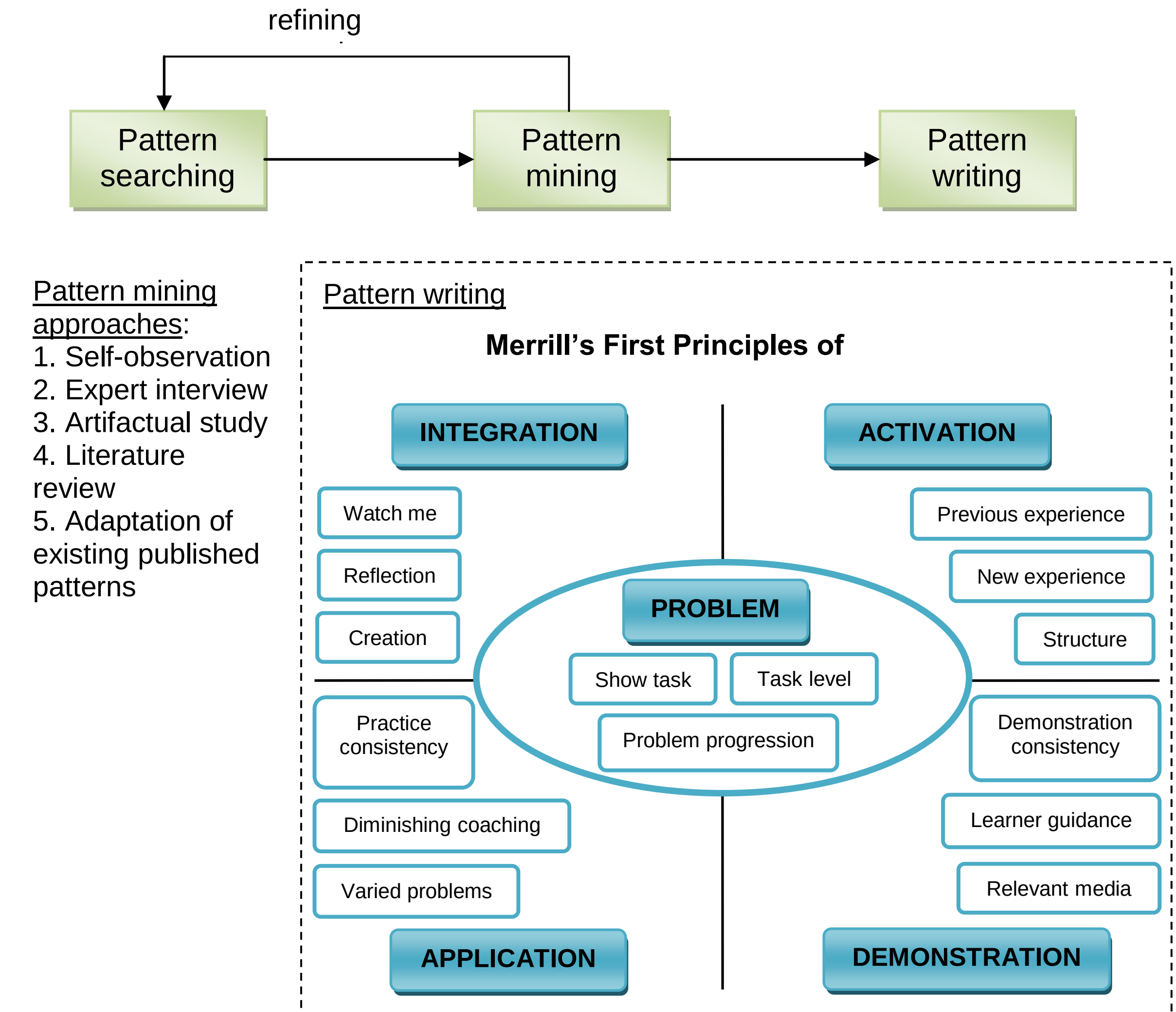

Figure 4-1. Theoretical framework and classification of design patterns

Catalog of Design Patterns

The Educational Modeling Language (EML) is the most commonly used modeling language in instructional design. In an attempt to visualize the learning scenario of each design pattern, this study adopted the EML of the Retbi, Merrouch, Idrissi, and Bennani, (2012). Figure 4-2 depicts the elements of the visual EML. *Action* is the notion of sequence, *Activity* is connected to *FlowConnector*, *Branch* is the condition for the action sequence, *FlowConnector* illustrates the adaptive action sequence, and *Synchronization* facilitates the implementation of actions.

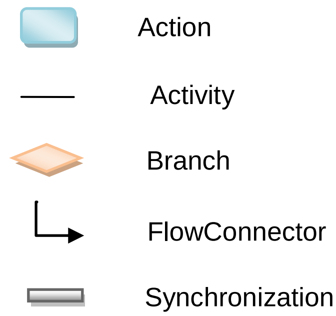

Figure 4-2. Elements of the visual Educational Modeling Language (Retbi et al., 2012)

Show Task Design Pattern

Pattern Name

Show Task

Also Known As

Learning Objective

Category

Problem

Context

Introducing a real-world problem or whole task to the learners. The instruction shows learners the task that they will learn to do or the problem that they will learn to solve when they finish a lesson.

Problem

Instructors state learning objectives at the beginning of a lesson. Learning objectives are often written in a form of observable activities, for instance “The learner will be able to...”. However, most learners do not really understand these abstract objective statements and what they will be able to do once they successfully complete a unit of learning.

Forces

Instead of stating abstract learning objectives, learners can understand the whole task better when beginning a lesson by showing them how to solve a real-world and authentic problem.

Solution

Demonstrate the first and complete whole task in a sequence that outlines the learning objective for the lesson. This demonstration should be the easiest task in a sequence. In practice, the first problem in a sequence should be the easiest one – so the learner progressively constructs a knowledge base by first understanding a basic concept and skill before moving to a more advanced problem. Furthermore, demonstration of the specific steps to solve a real-world problem or whole task provides a better orientation to the instructional materials as opposed to abstract objectives. The components of the whole task are demonstrated at a high-level so as not to overwhelm learners with too many details. For instance, after identifying a whole task, the initial instruction would be a fully worked example to show learners the steps in a problem-solving process, and thus reduce the cognitive load on their working memory.

Consequences

Worked examples help learners focus on the essential parts of the problems. Learners first study a worked example, then they solve a problem during independence practice. Providing learners with an effective cognitive support helps them to solve problems faster and avoid frustration.

Learning Scenario

Figure 4-37 illustrates the metamodel of the Show Task learning scenario.

Examples

The instruction for an open online course starts by demonstrating a complete whole task of a real-world problem, but the easiest version in a sequence. This initial demonstration provides an overview of all the whole task components that forms the learning objective for the lesson. Refer to the examples, the abstract learning objective for this course is to introduce the fundamental ideas in computing, and to teach learners how to read and write computer programs. The instructor starts the lesson by introducing a real-world problem in the context of building a web search engine as in Figure 4-3. Within the online content, an instructor video such as in Figure 4-4 can be used to show learners the complete whole task that they will learn to do or the problem that they will learn to solve. Building a search engine involves three main parts: finding data, building an index, and ranking pages. Further, the instructor demonstrates what learners will be able to do as a result of completing a course or lesson as in Figure 4-5.

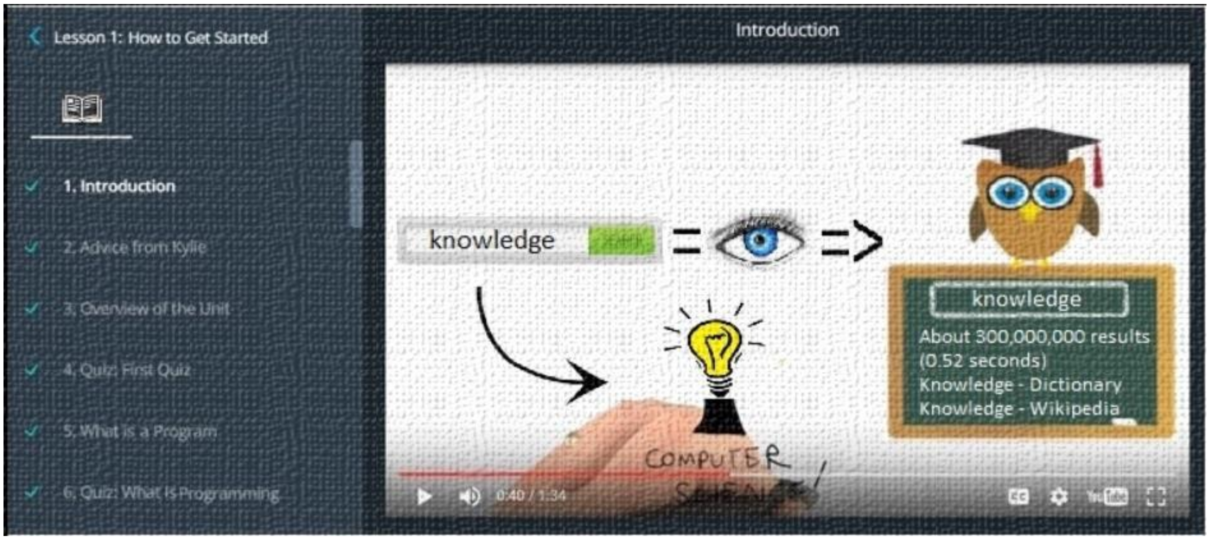

Figure 4-3. An instructor video introduces a real-world problem to the learners

Figure 4-4. An instructor video shows learners the complete whole task that they will learn to do

Figure 4-5. An instructor video demonstrates what learners will achieve by the end of the course

Related Patterns

Show Task is often implemented with Task Level and Problem Progression.

Supporting Research

1. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

2. Silber, K. H., & Foshay, W. R. (Eds.). (2010). *Handbook of improving performance in the workplace*. San Francisco, CA: Pfeiffer.

3. Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251-296.

Task Level Design Pattern

Pattern Name

Task Level

Also Known As

Problem Level

Category

Problem

Context

Effective learning requires learners to solve an authentic, real-world problem or whole task that allows them to explore and construct relevant concepts. Thus, it is important for learners to engage in the four levels of performance: the problem, the task, the operation, and the action level. Acquiring knowledge and skill in the context of the whole task helps learners to structure mental models about how these individual components are integrated into a complete performance.

Problem

Most instructions focus on teaching the prerequisites and decontextualized skills prior to introducing the real-world problems to the learners, which can greatly reduce their motivation to learn the materials. Learners do not feel a sense of ownership if the problems to be solved are uninteresting, irrelevant, and unappealing. The whole task or problem can be taught by breaking them into components. However, teaching components of the problem in isolation do not really help learners learn to solve the real-world problems in a meaningful way.

Forces

Learners should not be engaged only in the operation or action level, but also at the problem or task level in order to promote learning.

Solution

The instruction for open online courses should consider teaching the whole task, rather than individual task components, such as isolated actions or operations. This instructional approach or known as the contextualization of basic skills can be used to create explicit connections between the problem, the tasks for solving the problem, the operations that consist of the required tasks, and the actions that involve the operations. For example, website development skills are taught with direct reference to topics covered (how the web works, databases, building a basic blog, APIs, etc.) in a web development course. The application of skill components should take place after the demonstration of the first whole task in a sequence. New material then can be presented in small steps and practice can be provided after each step, but again this component should be related to the whole task. The practice is used to assess the knowledge or skill that learners have acquired at the end of the lesson.

Consequences

Following the contextualized instruction, learners will be likely to transfer the skills to solve a real-world problem when the instruction is connected to those topic areas rather than taught abstractly.

Learning Scenario

Figure 4-38 illustrates the metamodel of the Task Level learning scenario.

Examples

The whole task instruction consists of demonstrating a complete task to learners and allow them to practice the task as a single unit. Figure 4-6 and Figure 4-7 show an open online course – Introduction to Computer Science that provides learners with key computer science concepts and they will learn Python, a powerful programming language. Computer science is about how to solve a real-world problem such as building a web search engine by breaking them into smaller components and precisely describing a sequence of steps to solve these components. Theoretically, the three main components for building a web search engine are: (1) Finding data by building a web crawler – learners will learn this topic in learning unit 1-3, (2) Building an index to ensure fast response times to search queries – learners will learn this topic in learning unit 4-6, and (3) Ranking pages to get the best web pages for any given query – learners will learn this topic in learning unit 7-8. Thus, acquiring knowledge and skill in the context of whole tasks enables learners to form mental models of how those individual skills can be integrated into a complete performance.

Figure 4-6. Instructional strategies for task level

Figure 4-7. Introduction of the learning unit

Related Patterns

Task Level is often implemented with Show Task and Problem Progression.

Supporting Research

1. Johnson, E. B. (2002). *Contextual teaching and learning: What it is and why it's here to stay.* Thousand Oaks, CA: Corwin Press.

2. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

3. Perin, D. (2011). Facilitating student learning through contextualization: A review of evidence. *Community College Review, 39*(3), 268-295.

4. Simpson, M. L., & Nist, S. L. (2002). Encouraging active reading at the college level. In C. C. Block & M. Pressley (Eds.), *Comprehension instruction: Research-based best practices* (pp. 365-381). New York, NY: Guilford Press.

Problem Progression Design Pattern

Pattern Name

Problem Progression

Also Known As

Practice, Test or Quiz

Category

Problem

Context

After each learning module, a learner takes a quiz to ensure their readiness to continue. Effective learning requires a progression of problems – the problems start easy and then get harder. As learners' levels of expertise increase, instructional strategies should consider the alteration in the cognitive load to facilitate the transition from novice to expert.

Problem

Learners have to solve the whole task or some of the problems that are very complex. However, solving a single problem and receiving little or no guidance are likely not an effective way to help learners acquire problem-solving skills.

Forces

Instructional design strategies should be modified as a learner's knowledge increases. The expertise reversal effect refers to the reversal of the effectiveness of instructional strategies on learners as levels of knowledge in a domain change. Different levels of instructional guidance can result in different learning outcomes, depending on the learners' knowledge.

Solution

The research of cognitive load theory has shown that for novice learners with low prior knowledge, instruction consists of worked examples is more effective and efficient with lower mental effort than instruction consists of problem-solving. Scaffolding is certainly suitable in such conditions to provide novices with sufficient guidance. Also, learners must begin with a less complex problem in order to master a complex problem.

Learners are then given a more complex problem when the first problem is mastered. Practice with increasingly complex questions ensures the learners' skills gradually improve until they can solve more complex problems. Initially, novice learners should be provided with complete worked examples as full guidance. Learners study the problem by working through every step of the sequence in the worked examples. Then, the prompt can be gradually faded and replaced with completion tasks, for instance, ask learners to complete remaining steps of the Java code partially guided. Learners in the fading condition usually perform better on transfer tasks than learners who receive fully worked examples when solving practice tasks. Finally, as learners reach higher levels of knowledge in the subject area, problem solving practice with no guidance or self-explanation can be used. An active processing of worked examples can be encouraged by self-explanation. At this stage, the learner should independently provide the proper solution. Providing self-explanation prompts also benefited transfer. Although self-explaining increases the mental effort, to some extent it results in active processing of instructional materials, leading to greater learning outcomes. Table below suggests a possible sequence for problem progression.

Table 4-16. Instructional sequence for teaching components of the whole task

	Task 1	Task 2	Task 3	Task 4
Lesson 1	Show	Practice	Practice	Practice
Lesson 2	Show	Show	Practice	Practice
Lesson 3		Show	Show	Practice
Lesson 4		Show	Practice	Practice

A single demonstration of some components (lesson 1) is sufficient because they are easy to understand. Further demonstrations are required for comprehension because some components (lesson 2) are more complex. No demonstration in the early sequence, some components (lesson 3) are demonstrated for the later tasks. Although some components (lesson 4) are very complex, a single instance is sufficient for expert learners.

Consequences

Cognitive load on learners varies with different levels of expertise and has a great impact on learning performances. In the early stage of learning, cognitive load is high due to few schemas or knowledge structures are available. Studying worked examples that provide the clearest example can be better than solving the equivalent tasks. However, it is appropriate to increase learner control and to decrease instructor control as levels of expertise increase. During the intermediate stage when schemas are formed and working memory capacity is freed, germane load can be increased through completion tasks. In the final stage of learning, there must be sufficient working memory capacity to allow for more problem solving practice with no guidance or self-explanation. Overall, this instructional approach prepares learners to transition from early to final stage.

Learning Scenario

Figure 4-39 illustrates the metamodel of the Problem Progression learning scenario.

Examples

The extraneous cognitive load can be reduced by providing worked examples in the beginning, following by completion tasks and then full tasks. The examples show quizzes through a progression of increasingly complex problems, presenting different forms of instructional strategies. Problems must first start with a less complex in order to ensure learners' skills gradually improve as in Figure 4-8. Worked-examples are necessary to minimize extraneous cognitive load because this strategy provides novice learners with information needed to encourage comprehensive knowledge. Most research also suggested applying fading as in Figure 4-9 when teaching with worked-examples in actual settings. While self-explanation prompts as in Figure 4-10 could foster conceptual knowledge.

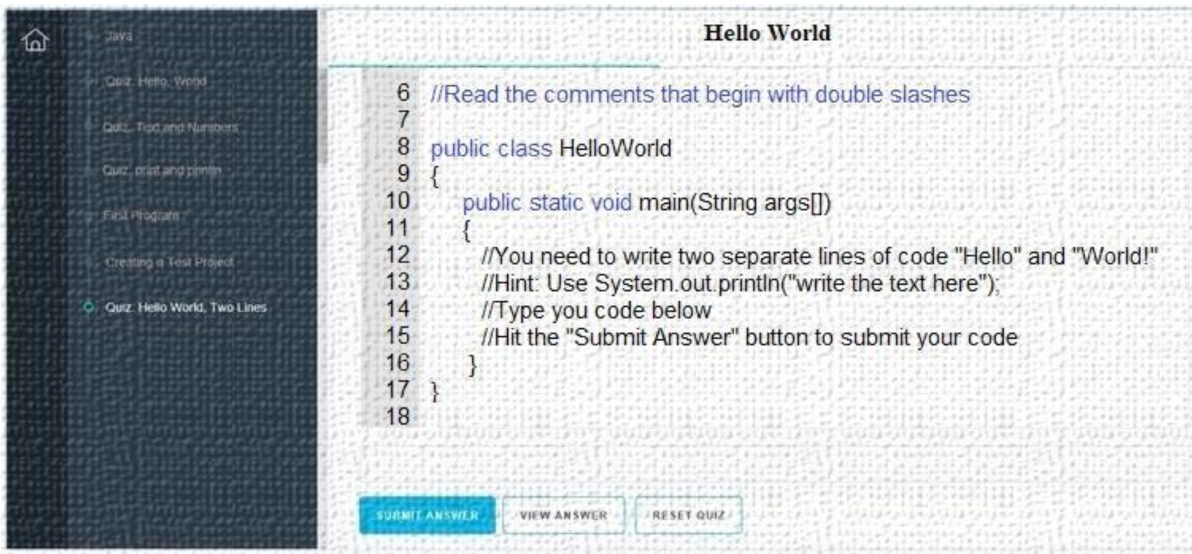

Figure 4-8. Quiz with a worked example approach

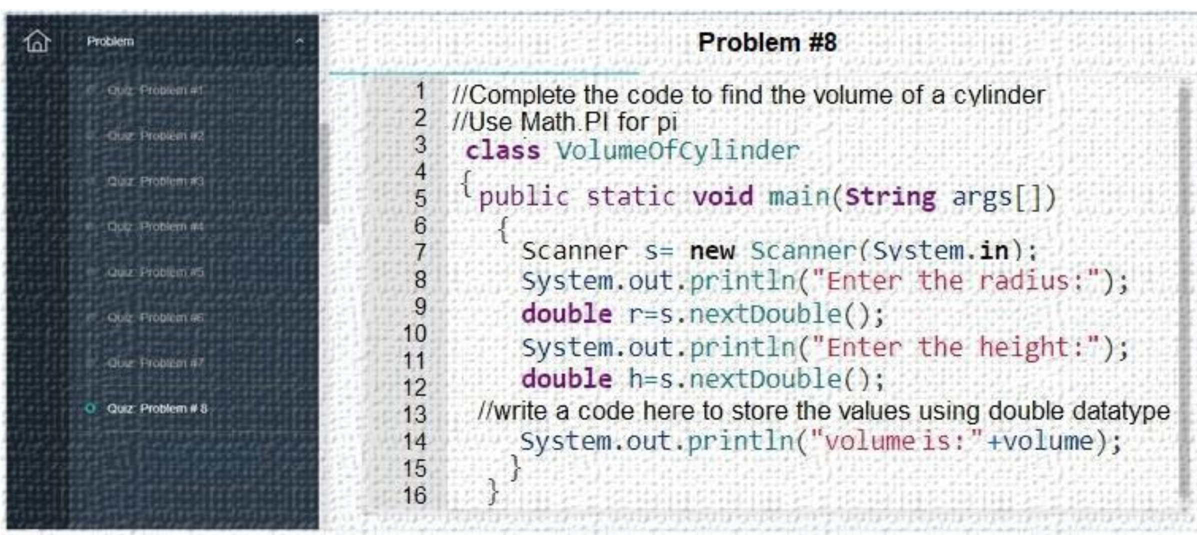

Figure 4-9. Quiz with a fading approach

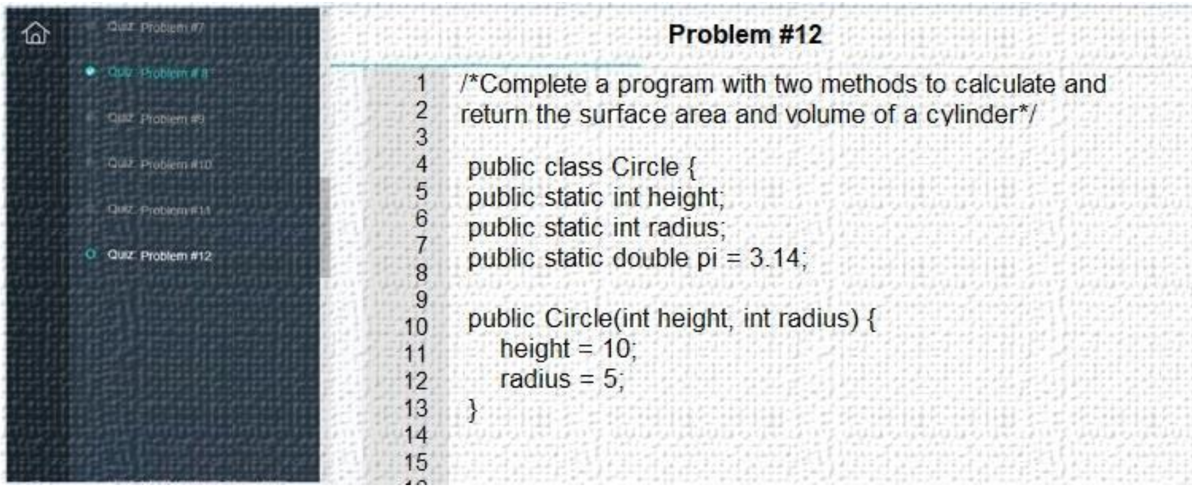

Figure 4-10. Quiz with a self-explanation approach

Related Patterns

Problem Progression is often implemented with Show Task and Task Level.

Supporting Research

1. Atkinson, R. K., & Alexander. R. (2007). Interactive example-based learning environments: Using interactive elements to encourage effective processing of worked examples. *Educational Psychology Review, 19*(3), 375-386.

2. Hilbert, T. S., Renkl, A., Schworm, S., Kessler, S., & Reiss, K. (2008). Learning to teach with worked-out examples: A computer-based learning environment for teachers. *Journal of Computer Assisted Learning, 24*(4), 316-332.

3. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

4. Salden, R. J. C. M., Koedinger, K. R., Renkl, A., Aleven, V., & McLaren, B. M. (2010). Accounting for beneficial effects of worked examples in tutored problem solving. *Educational Psychology Review, 22*(4), 379-392.

5. Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251-296.

Previous Experience Design Pattern

Pattern Name

Previous Experience

Also Known As

Prior Knowledge

Category

Activation

Context

With an open online course, the diversity of learners' prior experience is expected to be broad and greatly variable. When learners have relevant prior knowledge, the instruction should activate their existing experience to link previously learned information to the new knowledge.

Problem

One of the challenges of open online courses is activating learners' prior knowledge to novel situations. Some instructions require learners to complete a pretest to assess the level of their prior knowledge at the beginning of each learning unit. This instruction is sometimes not effective as learners do not understand the new material to be learned without engaging in any learning activity.

Forces

When learners understand some of the new material to be learned, their prior knowledge can be activated through a relevant learning activity to demonstrate what they already know about the topic.

Solution

Instruction should direct learners to recall, relate, describe or apply relevant prior knowledge that can be served as a foundation for the new knowledge to be learned. Activating prior knowledge can be done through starting a lesson by introducing a new topic and demonstrating relevant examples. Learners then can be instructed to complete multiple-choice questions or short answer to probe their prior knowledge. It is important to include questions that most learners can answer correctly as a starting point for activating prior knowledge. Also, learners should know that they will not be graded for the assessment. The information from the assessments should be shared with the learners as appropriate.

Consequences

The activation of prior knowledge helps learners connect previously learned information to the new learning material.

Learning Scenario

Figure 4-40 illustrates the metamodel of the Previous Experience learning scenario.

Examples

The prior knowledge that learners bring to a learning environment is a critical factor influencing new learning. Figure 4-11 shows messages from the instructor to remind that the first quiz is intended to check their understanding, and they will not be graded for the assessment. Figure 4-12 illustrates the first quiz that relates to the learning goal of the lesson. For the purpose of activating prior knowledge, it is important to provide questions that most learners can answer correctly. Then, the instructor demonstrates a new topic by introducing "What is a program" as in Figure 4-13. Following the demonstration, learners can take the quiz as many times as they want without penalty. Figure 4-14 depicts a pretest to assess learners' prior knowledge. Some questions are pretty straightforward to check for learners' understanding of what have been covered. Such questions ensure the information presented to learners is adequate in building the necessary knowledge for them to understand the new material better. There are solution videos to the quiz and if learners get the quiz right, they can still refer to the helpful information and tips or even new material in the videos. While interactive environments may increase essential cognitive load, it is not sufficient for learners to just actively process the learning material, rather it is important for them to process information with a focus on central concepts and principles.

Figure 4-11. Messages from the instructor for the first quiz

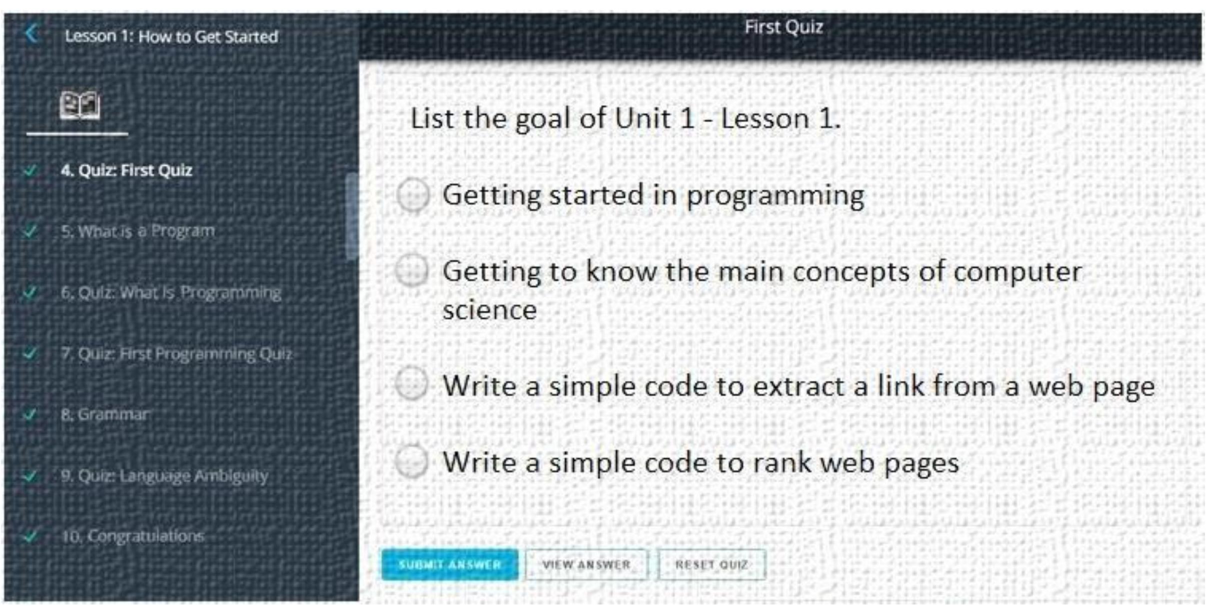

Figure 4-12. The first quiz for the Intro to Computer Science course

Figure 4-13. An instructor video demonstrates a new topic “What is a Program”

Figure 4-14. Pretest to assess learner’s prior knowledge

Related Patterns

Previous Experience is often implemented with New Experience and Structure.

Supporting Research

1. Hone, K. S., & El Said, G. R. (2016). Exploring the factors affecting MOOC retention: A survey study. *Computers & Education, 98*, 157-168.

2. Kalyuga, S. (2012). Role of prior knowledge in learning processes. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 2886-2888). Heidelberg, Germany: Springer-Verlag.

3. Margaryan, A., Bianco, M., & Littlejohn, A. (2015). Instructional quality of massive open online courses (MOOCs). *Computers & Education, 80*, 77-83.

4. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

New Experience Design Pattern

Pattern Name

New Experience

Also Known As

Provide Experience

Category

Activation

Context

The instruction should provide learners with relevant knowledge to serve as a foundation for a new experience. The instruction should also help learners feel confidence in their ability to acquire a new knowledge and skill, as well as to realize its relevance.

Problem

Most instruction begins with abstract representations, but without providing relevant experience to the learners. Learners feel overwhelmed when the new and unfamiliar material is introduced immediately without sufficient support. As prior knowledge gained from experience affects the formation of the learners' mental models, they tend to memorize the new material.

Forces

In opposition to a traditional classroom setting, open online learning assumes learners can self-regulate their own learning. Thus, providing relevant experience to the learners before beginning instruction on any new material is necessary.

Solution

Learner engagement can be achieved by clearly communicating the benefit of the learning goals to the learners, and helping them connect their interests and personal goals to the learning goals. In a traditional classroom setting, instructors help learners practice new information by asking a large number of questions. An open online course does not have the capacity to support such interaction due to the large numbers of geographically dispersed learners for synchronous sessions. Thus, it should become a common practice to provide learners with a relevant experience before introducing a new learning material by presenting a learning goal and giving more examples.

Consequences

Preparing learners prior to introducing a new experience can avoid them to memorize the new material. Learners can actively engage in a course and stay on track.

Learning Scenario

Figure 4-41 illustrates the metamodel of the New Experience learning scenario.

Examples

Figure 4-15 shows that learners are presented with the introductory material, such as the definition of the design principles and the explanation of complex concepts prior to independent practice. The instructor further demonstrates another example that relevant to the new topic as in Figure 4-16. The use of multiple explanations and examples will provide learners with a brief introduction to the new concepts to be learned.

Figure 4-15. An instructor video presents the introductory materials

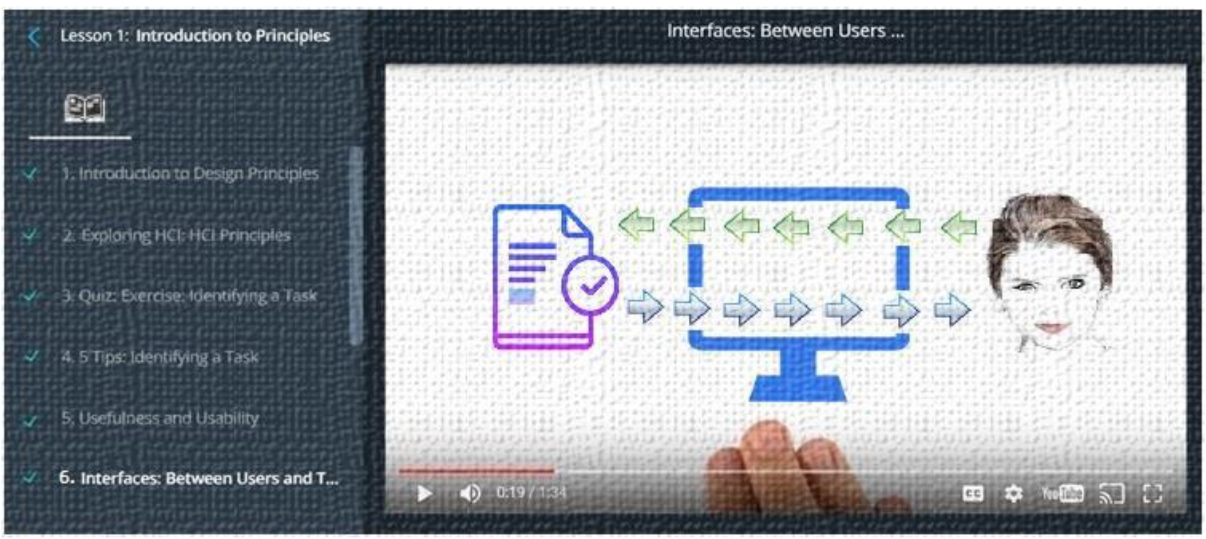

Figure 4-16. An instructor video demonstrates a relevant example

Related Patterns

New Experience is often implemented with Previous Experience and Structure.

Supporting Research

1. Hone, K. S., & El Said, G. R. (2016). Exploring the factors affecting MOOC retention: A survey study. *Computers & Education, 98*, 157-168.

2. Kalyuga, S. (2012). Role of prior knowledge in learning processes. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 2886-2888). Heidelberg, Germany: Springer-Verlag.

3. Margaryan, A., Bianco, M., & Littlejohn, A. (2015). Instructional quality of massive open online courses (MOOCs). *Computers & Education, 80*, 77-83.

4. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

Structure Design Pattern

Pattern Name

Structure

Also Known As

Schema

Category

Activation

Context

The instruction should encourage learners to activate their mental models for organizing a new knowledge when they have relevant mental models. Otherwise, instruction should provide a structure that enables learners to build appropriate mental models for a new knowledge.

Problem

Learners have to build a new set of interrelated skills based on their previously acquired mental models in order to solve complex problems. Too often learners activate inappropriate mental models that increase their mental efforts and results in errors when trying to solve new problems.

Forces

Activation of mental models helps learners to stimulate their mental models that can be modified to integrate the existing knowledge into the new knowledge.

Solution

The instruction should encourage learners to recall a structure for organizing the newly acquired knowledge and skill. Graphic organizers such as an advance organizer can be used to help learners organize the interrelationships among knowledge components. Advance organizers are also useful for activating and building schema and help learners remember, retain, and understand the new material. While motivational themes can be used for organizing structure as they help learners to activate appropriate mental models, provided that the themes relevant to the new content.

Consequences

The activation of mental models can increase cognitive load in learners that enable them to acquire the necessary knowledge and skill. Learners then can build the necessary organizational schema for the new knowledge.

Learning Scenario

Figure 4-42 illustrates the metamodel of the Structure learning scenario.

Examples

Graphic organizers can be presented to the learners before a new content is introduced. Figure 4-17 shows an advance organizer to connect general knowledge to the new information. This graphic organizer is not only presenting the overview of the learning unit, but also sharing ideas and techniques of the new material to be learned. Encouraging learners to recall previous relevant experience can activate appropriate mental models to facilitate the acquisition of new skills. Mental models can be modified to allow learners integrate the previously acquired knowledge to the new knowledge. Those learners' internal representations can be used to construct a framework for organizing their new contents. Figure 4-18 shows motivational themes to serve as an organizing structure. These motivational themes activate appropriate mental models to promote instructional effectiveness and result in the increasing of cognitive load necessary to acquire the new knowledge.

Figure 4-17. Advance organizer

Figure 4-18. Motivational themes

Related Patterns

Structure is often implemented with Previous Experience and New Experience.

Supporting Research

1. Hone, K. S., & El Said, G. R. (2016). Exploring the factors affecting MOOC retention: A survey study. *Computers & Education, 98*, 157-168.

2. Kalyuga, S. (2012). Role of prior knowledge in learning processes. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 2886-2888). Heidelberg, Germany: Springer-Verlag.

3. Margaryan, A., Bianco, M., & Littlejohn, A. (2015). Instructional quality of massive open online courses (MOOCs). *Computers & Education, 80*, 77-83.

4. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

Demonstration Consistency Design Pattern

Pattern Name

Demonstration Consistency

Also Known As

Show Me

Category

Demonstration

Context

Each different types of problems require different knowledge structures and different component skills. Hence, the demonstration of the content to be taught should be consistent with the intended learning outcomes for effective learning.

Problem

Too often the demonstration is inconsistent with the type of skills to be learned. Also, the most common instruction is the presentation of information and is followed by memorization. The memorization of information based on repetition is ineffective as learners do not have the opportunity to apply what has been learned. Too much "information and memorization" instruction does not allow learners to acquire problem-solving skills.

Forces

Effective learning occurs when the demonstration of the skills being promoted is consistent with the content to be taught.

Solution

The instruction of an open online course should demonstrate what is to be learned. For better understanding of abstract ideas, examples and non-examples can be used to teach learners the concepts, principles, and theories. Demonstrations are useful to show the sequence of procedures to the learners. Visualization is a representation of a set of information, situation or object such as an image or chart, which is practical to visualize processes. Modeling can be used to describe the interactions between objects and the overall behavior of a particular system, such as sequence diagrams or use case diagrams. Overall, the instruction should consistent with the desired learned performance in order to promote the development of the cognitive structures.

Consequences

Specific techniques such as modeling, simulations, and visualizations to demonstrate what is being taught are more effective than just presenting information to learners.

Learning Scenario

Figure 4-43 illustrates the metamodel of the Demonstration Consistency learning scenario.

Examples

One of the best ways to teach abstract concepts and complex ideas is by showing an example. Figure 4-19 illustrates an example to help learners understand the abstract idea of objects in the context of object-oriented programming. An interactive software program could be a rational tool to support examples and to foster understanding among learners. However, several limitations must be taken into account in interpreting the technique associated with cognitive load theory. Examples may not work for all types of learners, especially the advanced ones and the methods in which a particular learner processes the examples can have a major impact on the effectiveness of the learning experience. While a demonstration or tutorial video is an instructional program that provides step-by-step information to complete a task. Figure 4-20 shows a video to demonstrate how to create objects on the BlueJ programming environment. This demonstration video is aimed to help learners familiarize with the capabilities of the BlueJ environment. BlueJ is a Java development environment specifically designed for teaching at an introductory level.

Figure 4-19. An example to show the abstract idea of objects

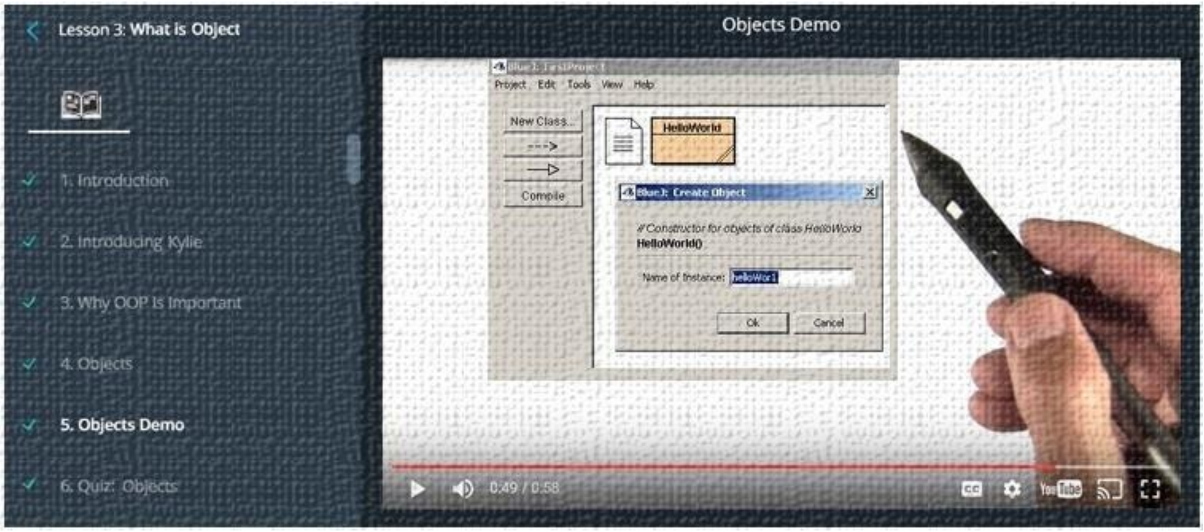

Figure 4-20. A demonstration or tutorial video to create objects

Related Patterns

Demonstration Consistency is often implemented with Learner Guidance and Relevant Media.

Supporting Research

1. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

2. Moller, L., Huett, J. B., & Harvey, D. M. (2009). *Learning and instructional technologies for the 21st century: Visions of the future*. New York, NY: Springer.

3. Morrison, G. R., Ross, S. M., Kalman, H. K., & Kemp, J. E. (2013). *Designing effective instruction*. Hoboken, NJ: John Wiley & Sons.

4. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models*. New York, NY: Routledge.

5. Retalis, S., Georgiakakis, P., & Dimitriadis, Y. (2006). Eliciting design patterns for e-learning systems. *Computer Science Education, 16*(2), 105-118.

Learner Guidance Design Pattern

Pattern Name

Learner Guidance

Also Known As

Help Me

Category

Demonstration

Context

Provide multiple means of representations for approaching different contents, so learners have multiple ways of understanding the information presented.

Problem

Some instruction does not provide learners with multiple means of representation. Transfer of learning does not occur with a single representation as learners cannot make connections between concepts presented.

Forces

Transfer is promoted when the instruction provides learners with the "attention-focusing function" to facilitate knowledge acquisition early in the learning so they can focus on the relevant information.

Solution

The instruction should provide learners with appropriate levels of guidance. Enabling learners relate their personal experiences and perceptions to the current topic, such as through reflections and discussions are an effective way to provide relevance. This guidance helps learners relate the previously acquired knowledge and skill structures with the current information. Instead of passively observing the demonstration, learning from demonstrations can be improved when learners actively engage in peer discussion and peer demonstration. Learners can head to the forums for interaction with the open online course community. Another form of guidance is to provide learners with multiple means of representations as learners differ in the ways they perceive the information presented. Learners can relate the content or information to specific instances as a result of the demonstrations. Thus, providing options for representation is essential in open online courses.

Consequences

Presenting the relevant content helps learners develop into self-regulated and motivated learners. Transfer of learning occurs when multiple means of representations are used as learners are allowed to make connections between concepts. Through multiple representations, learners can develop the mental models necessary for describing a more detailed and accurate description of the information.

Learning Scenario

Figure 4-44 illustrates the metamodel of the Learner Guidance learning scenario.

Examples

New information can be presented to learners in varied ways. Figure 4-21 and Figure 4-22 are part of a MOOC, Introduction to Java Programming about basic of Java interfaces and on how to implement interfaces in class. Figure 4-21 illustrates a Java programming tutorial, while Figure 4-22 presents a Java interface example, with a live practical demo that are very useful for beginners. Figure 4-23 is another type of learner guidance – a reflection task to enable learners relate their personal experiences to the topic. Learners are able to critically review their own learning process through self-reflection. Also, learning can be enhanced through peer interaction in a discussion forum as in Figure 4-24. Discussions provide opportunities for learners to articulate and defend their positions, accept different opinions, foster intellectual agility, and evaluate artifacts.

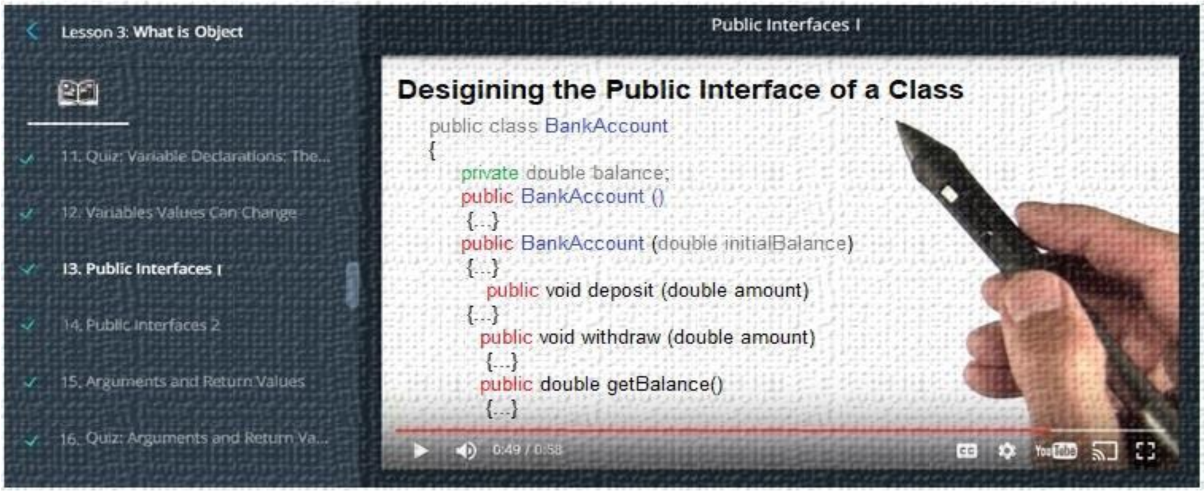

Figure 4-21. Java interface example

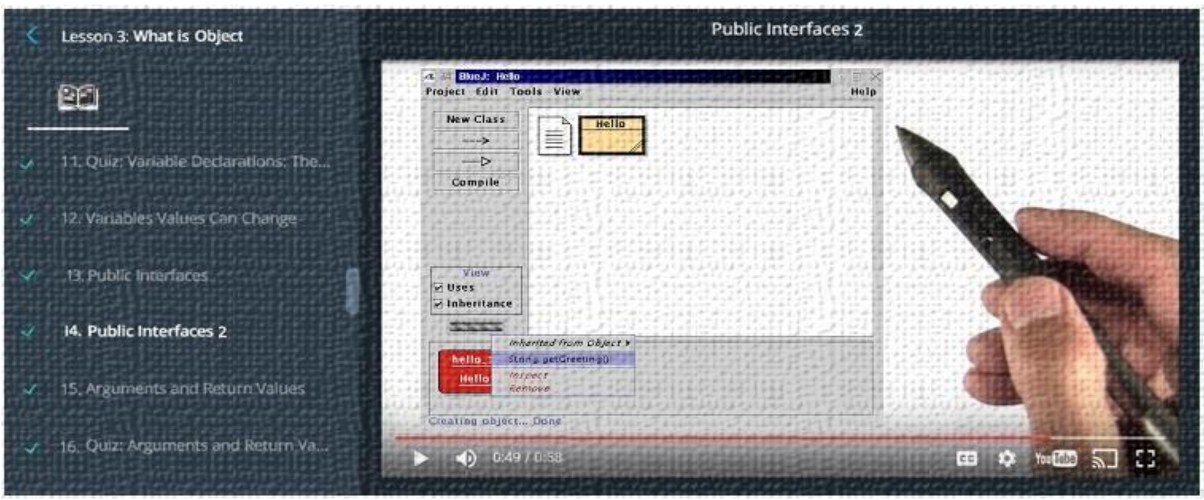

Figure 4-22. Demonstration video

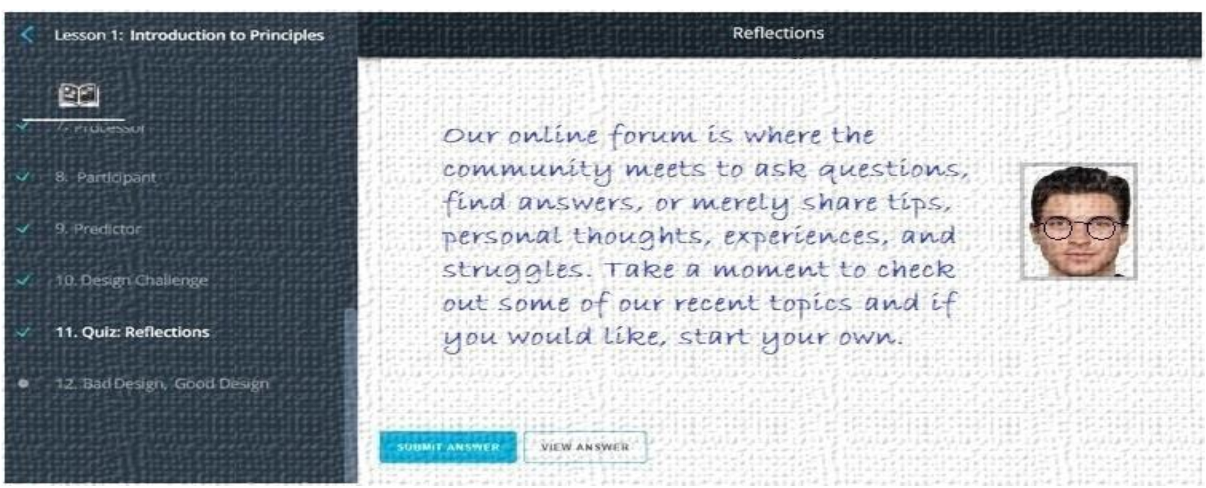

Figure 4-23. Reflection task

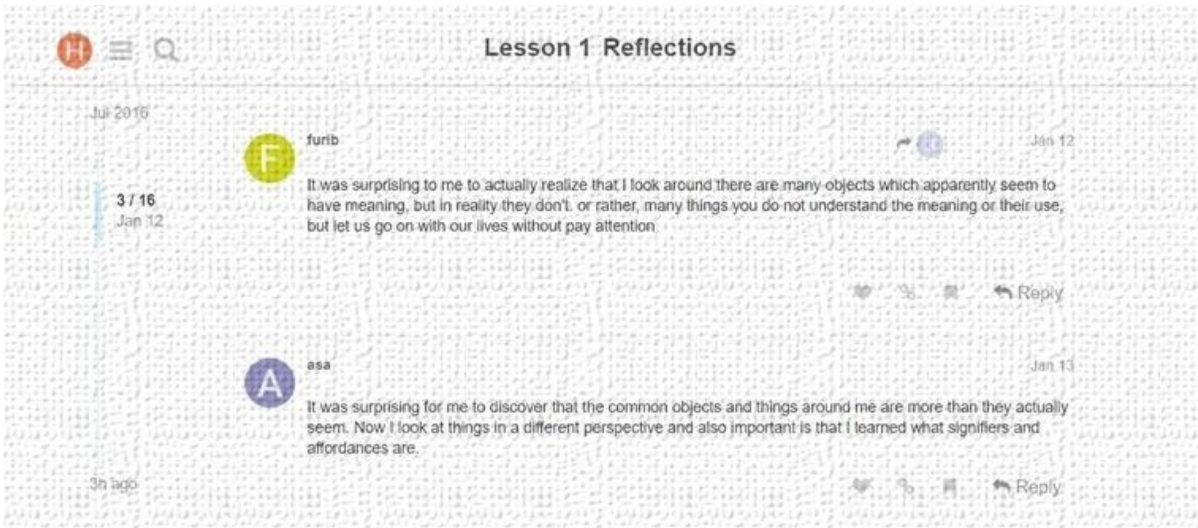

Figure 4-24. Peer interaction

Related Patterns

Learner Guidance is often implemented with Demonstration Consistency and Relevant Media.

Supporting Research

1. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

2. Moller, L., Huett, J. B., & Harvey, D. M. (2009). *Learning and instructional technologies for the 21st century: Visions of the future*. New York, NY: Springer.

3. Morrison, G. R., Ross, S. M., Kalman, H. K., & Kemp, J. E. (2013). *Designing effective instruction*. Hoboken, NJ: John Wiley & Sons.

4. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models*. New York, NY: Routledge.

5. Retalis, S., Georgiakakis, P., & Dimitriadis, Y. (2006). Eliciting design patterns for e-learning systems. *Computer Science Education, 16*(2), 105-118.

Relevant Media Design Pattern

Pattern Name

Relevant Media

Also Known As

Instructional Media

Category

Demonstration

Context

Integrating and infusing social media, online instructional tools, video, and digital content in ways that connect and engage learners with course content.

Problem

Some instruction may use irrelevant audio, text, and visuals to deliver digital contents. Using this combination of multimedia can potentially hurt learning as it competes for the learner attention and result in the increasing of cognitive load.

Forces

The effective use of digital media such as audio, graphics, and text can create a highly engaging course and thus optimize learning.

Solution

Digital content can be delivered through tablet recording and presentation software, in which the instructor will point or motion to things, and learners can see the instructor's mouse pointer interacts with the content. Instructional videos with graphics should be explained solely by audio, rather than by both audio and text in order to facilitate the transfer of learning. For instance, using audio narration for explaining a complex graphic in a topic when the elements of instructional media consist of on-screen graphics. Graphics then should be selected based on the type of contents. In contrast, videos presented with narration of on-screen text are more effective than videos presented with narration alone when there is no graphic on the screen. Although graphics such as charts, diagrams, and photographs can improve learning, it is important to choose the ones that are congruent with the learning goal.

Consequences

Learning is effective when the combination of multimedia does not compete for the learner attention.

Learning Scenario

Figure 4-45 illustrates the metamodel of the Relevant Media learning scenario.

Examples

Working memory is a limited resource that is responsible for information processing. The use of graphics with audio can maximize the capacity of working memory. Figure 4-25 shows a video with audio narration for explaining a graphic in a topic that is complex and unfamiliar to the learners. Adding a graphic to the content can improve learning, provided that the illustration is congruent with the instructional message. Placing related text to the graphic close to each other on the screen also can help to improve learning.

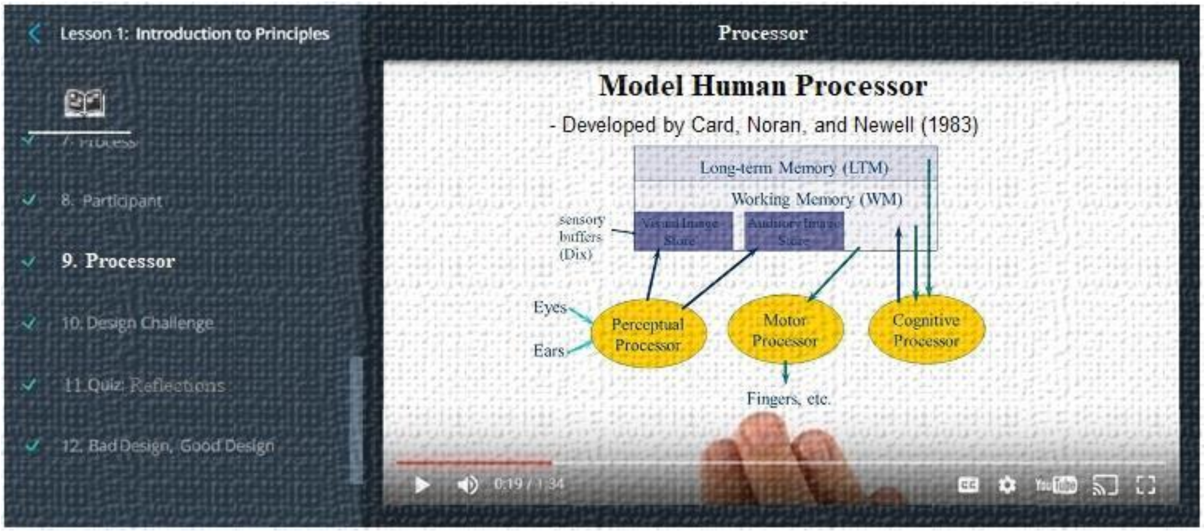

Figure 4-25. Graphic with audio narration

Related Patterns

Relevant Media is often implemented with Demonstration Consistency and Learner Guidance.

Supporting Research

1. Mayer, R. E. (2001). *Multimedia learning*. New York: Cambridge University Press.

2. Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43-52.

3. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

4. Morrison, G. R., Ross, S. M., Kalman, H. K., & Kemp, J. E. (2013). *Designing effective instruction*. Hoboken, NJ: John Wiley & Sons.

5. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models*. New York, NY: Routledge.

Practice Consistency Design Pattern

Pattern Name

Practice Consistency

Also Known As

Practice Alignment

Category

Application

Context

After observing effective demonstrations, learners should get chances to engage in application of the newly acquired skill and knowledge. The instruction should include application (practice) and assessment (tests) that consistent with the implied learning objectives.

Problem

Learning is ineffective when learners engage in practice that is inconsistent with the intended goals of the instruction.

Forces

Learners can have a meaningful interaction with the content by getting a chance to actively apply and practice their newly acquired knowledge and skills. Aligning practice with learning goals can help enhance the learner-content interaction.

Solution

Different types of skills require different practice. Instruction then should provide practice that is consistent with the types of skills to be acquired. However, it is important to ensure the consistency of the practice with the desired instructional goal. Some of the practice that can be offered to the learners are as follows:

- Learners can have a meaningful interaction with the content by getting a chance to actively apply and practice their newly acquired knowledge and skills.
- Aligning practice with learning goals can help enhance the learner-content interaction.

Solution

Different types of skills require different practice. Instruction then should provide practice that is consistent with the types of skills to be acquired. For instance, a common practice for the concept classification is recall and recognition. This memory retrieval is a process of remembering information stored in a long-term memory. Examining a worked example is another practice for the concept classification. However, it is important to ensure the consistency of the practice with the desired instructional goal. Table 4-17 depicts some of the practice that can be offered to the learners in an open online course.

Table 4-17. Suggestion for practice

Types of Skill	Practice example
Concept classification	• Recall and recognition – the more learners practice a piece of information, the more they likely remember it. • Review – learners examine a worked example. • Describe – learners identify, sort, rank, and label each component after review a video presenting a task and the core ideas.
Procedure	• Do – perform a procedure using a method and tool to produce outputs.
Predicting consequences	• Predict – learners assume the outcome of a process. • Discuss – learners head to the online forums for discussion with the online course community. • Reflect and share – learners take a moment to reflect on what have been learned and share their reflections with the rest of the online forums.

Consequences

The interaction occurs in an open online course is much different than the interaction in a traditional classroom due to the instructional media used in the virtual platform. Effective design of a learner-to-content interaction can have a positive impact on learners' satisfaction and learning.

Learning Scenario

Figure 4-46 illustrates the metamodel of the Practice Consistency learning scenario.

Examples

The learner-content interaction occurs when learners engage with the course content and participate in independent practice. The continuous and extensive interaction with the content leads to higher levels of learning and greater satisfaction with the course. One way to improve the learner-content interaction is through the consistency of practice and posttest with the desired learning goal. Figure 4-26 illustrates a practice that requests learners to do the procedure and produce an output. Figure 4-27 shows a practice that requests learners to identify and match some methods with their classes after reviewing a worked example.

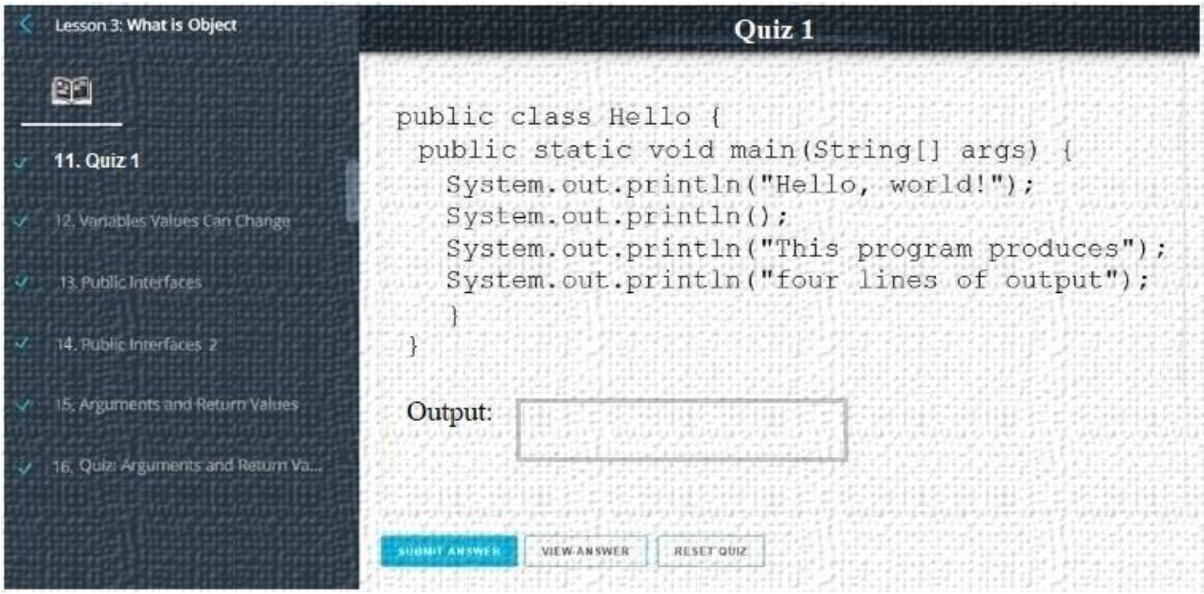

Figure 4-26. Procedure and produce output practice

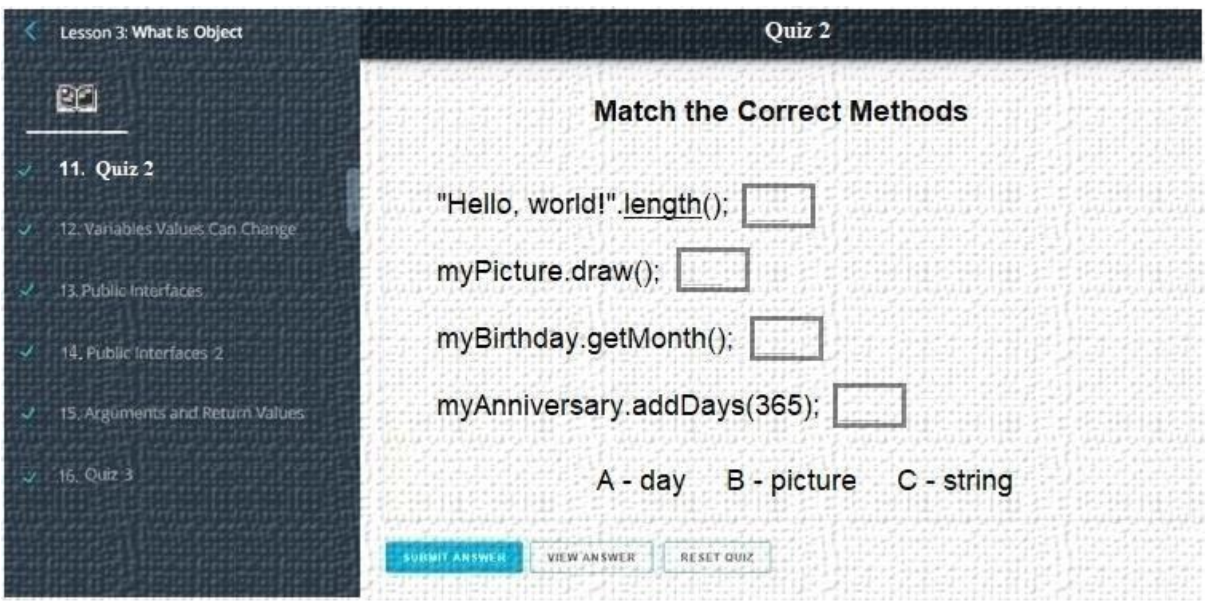

Figure 4-27. Identify and label practice

Related Patterns

Practice Consistency is often implemented with Diminishing Coaching and Varied Problems.

Supporting Research

1. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

2. Morrison, G. R., Ross, S. M., Kalman, H. K., & Kemp, J. E. (2013). *Designing effective instruction*. Hoboken, NJ: John Wiley & Sons.

3. Retalis, S., Georgiakakis, P., & Dimitriadis, Y. (2006). Eliciting design patterns for e-learning systems. *Computer Science Education, 16*(2), 105-118.

4. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models*. New York, NY: Routledge.

Diminishing Coaching Design Pattern

Pattern Name

Diminishing Coaching

Also Known As

Scaffolding

Category

Application

Context

Coaching is a fundamental role in knowledge transfer and retention. Worked examples, for instance, provide learners with ready-made solutions to problems and step-by-step instructions that assist learners construct deep understanding of the content areas. Providing one-to-one video solution and discussion on quizzes are some ways of increasing learners' performance and persistence.

Problem

An instructor is the focal point in the traditional classroom and does most of the teaching, coaching, questioning, and responding to learners. Due to the lack of face-to-face interaction with the live instructor, online learners often feel disconnected, uninterested, and unmotivated to complete the task. Some learners are unable to demonstrate their ability when learning complex topics in open online environments without scaffolding. They also fail to increase understanding of the complex concepts taught.

Forces

When learners are having difficulty with a problem-solving task, the instruction should allow learners to access help or provide them with gradually diminished coaching. Instead of right-wrong feedback, instruction should provide practice with corrective feedback to learners, as well as an indication of progress.

Solution

Scaffolding is an effective instruction with the idea of guiding learners early in the learning process, but this support will gradually diminish as learners gain independence and the coaching is gradually diminished as learners become more competent. Work examples enable learners to observe a demonstration of a correct solution to the problem. By observing a worked example, learners watch the expert video, in which they can see the instructor using their hands interact with the content, or even using their hands to point or motion to things. Learners are encouraged to pause the video and examine the information in the video. On the other hand, feedback is one of the most important types of learner guidance that enables learners to reflect on their learning. Making mistakes is a natural part of learning. Learners make mistakes and they learn best when they observe solutions or answers on how to identify the mistake, and how to avoid the mistake in the future. Within a MOOC, learners receive feedback in a form of error detection and correction through automated feedback. Overall, learning is promoted when learners are provided with coaching and appropriate feedback during problem-solving tasks.

Consequences

Learners can actively apply their new knowledge through an application that involve interactions with the content, and other learners. When learners practice and apply their newly acquired knowledge and skill, they are provided with sufficient guidance and feedback on performance. Scaffolding such as worked examples provides learners with step-by-step instructions and ready-made solutions in solving problems to help learners develop a deeper understanding of the instruction.

Learning Scenario

Figure 4-47 illustrates the metamodel of the Diminishing Coaching learning scenario.

Examples

Presenting learners with appropriate guidance such as scaffolding helps to reduce the cognitive load of the learners as they encounter the problems to be solved. Figure 4-28 shows a worked example, as a coaching tool that provides learners the first experience with the material. Learners can reflect on their prior experiences with the content and enable them to construct meaning from the instruction. Figure 4-29 illustrates the automated feedback when learners make a mistake during a quiz.

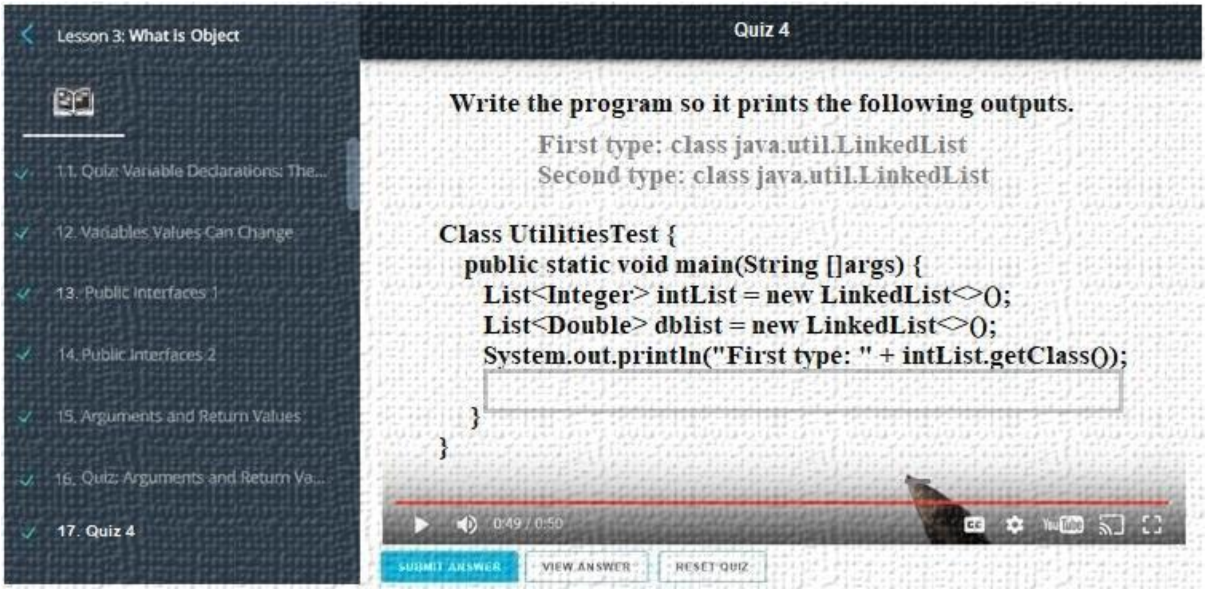

Figure 4-28. Worked example

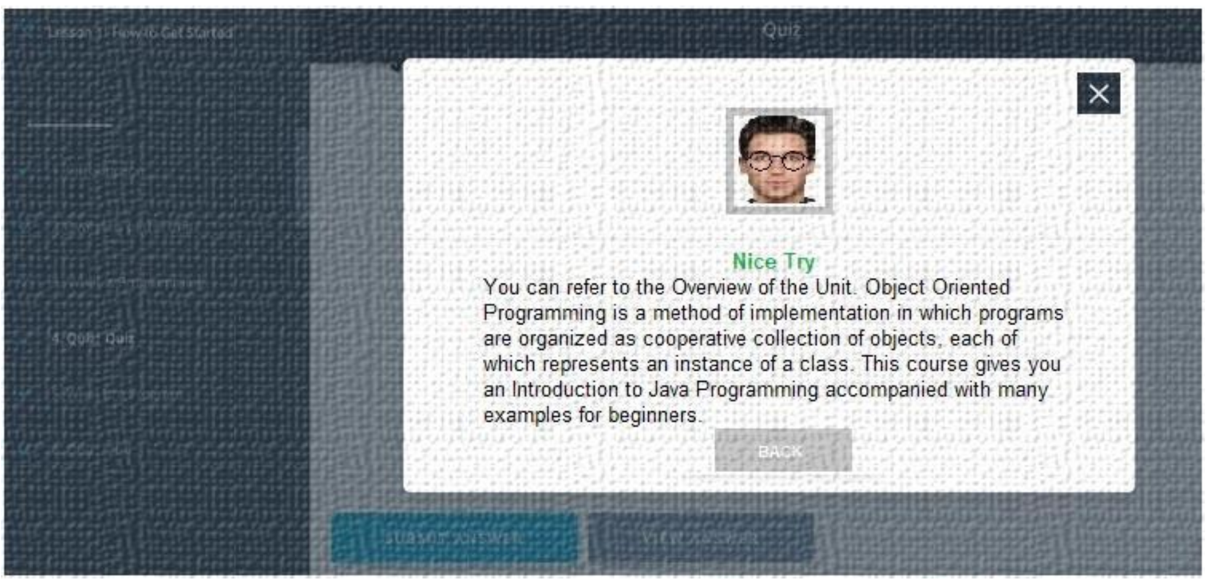

Figure 4-29. Automated feedback

Related Patterns

Diminishing Coaching is often implemented with Practice Consistency and Varied Problems.

Supporting Research

1. Atkinson, R. K., & Alexander. R. (2007). Interactive example-based learning environments: Using interactive elements to encourage effective processing of worked examples. *Educational Psychology Review, 19*(3), 375-386.

2. Hilbert, T. S., Renkl, A., Schworm, S., Kessler, S., & Reiss, K. (2008). Learning to teach with worked-out examples: A computer-based learning environment for teachers. *Journal of Computer Assisted Learning, 24*(4), 316-332.

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4. Salden, R. J. C. M., Koedinger, K. R., Renkl, A., Aleven, V., McLaren, B. M. (2010). Accounting for beneficial effects of worked examples in tutored problem solving. *Educational Psychology Review, 22*(4), 379-392.

5. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models*. New York, NY: Routledge.

6. Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251-296.

Varied Problems Design Pattern

Pattern Name

Varied Problems

Also Known As

Variability of Practice

Category

Application

Context

Learners should be provided with a sequence of varied problems for effective learning. Presenting learners with a range of divergent examples provides multiple opportunities for them to apply new knowledge or skill to a variety of problems.

Problem

Some instructions provide learners with a single problem. Solving a single problem enables learners use only one perspective in perceiving a problem. Apparently, learners have not learned a cognitive skill much just by applying knowledge to a single problem. An instructional strategy that consists of a single problem is far less effective than a varied sequence of problems.

Forces

Learners should apply their new knowledge or skill to multiple problems.

Solution

Learners are presented with a sequence of varied problems, but the problems should not be too similar to the demonstrated examples in order to avoid learners engage in limited reconstruction of mental models. Learners should be provided with new and challenging varied problems for application. Presenting learners with a range of divergent examples can help them to construct an adequate mental model to solve multiple problems. Overall, variability of practice enables generalization of cognitive schemas and enhances learning transfer.

Consequences

When learners are provided only with a single problem, they may not have developed the nuanced mental model required to deal with more complex and varied problems. In contrast, learners are able to continually improve their mental model when they attempt to solve a sequence of varied problems.

Learning Scenario

Figure 4-48 illustrates the metamodel of the Varied Problems learning scenario.

Examples

Learners are given a series of problems to complete as an independent practice. A worked example is an instructional strategy that was derived from cognitive load theory and most notably, used to teach cognitive procedures such as science, technology, engineering, and mathematics which have a great deal in common when it comes to learning requirements. Worked examples show every step of the problem-solving process while a learner studies the problem by working through every step of the example. After learners observe a worked example, they will solve a sequence of mixture problems as in Figure 4-30 and Figure 4-31. The figures below show quizzes for a fundamental data types lesson in the course – Introduction to Java Programming. Figure 4-30 illustrates the practice for number types, while Figure 4-31 shows the practice of arithmetic operations. Having learners applies new knowledge allows them to experience how experts approach and solve multiple problems, hence learners will be prepared to face the real-world problems.

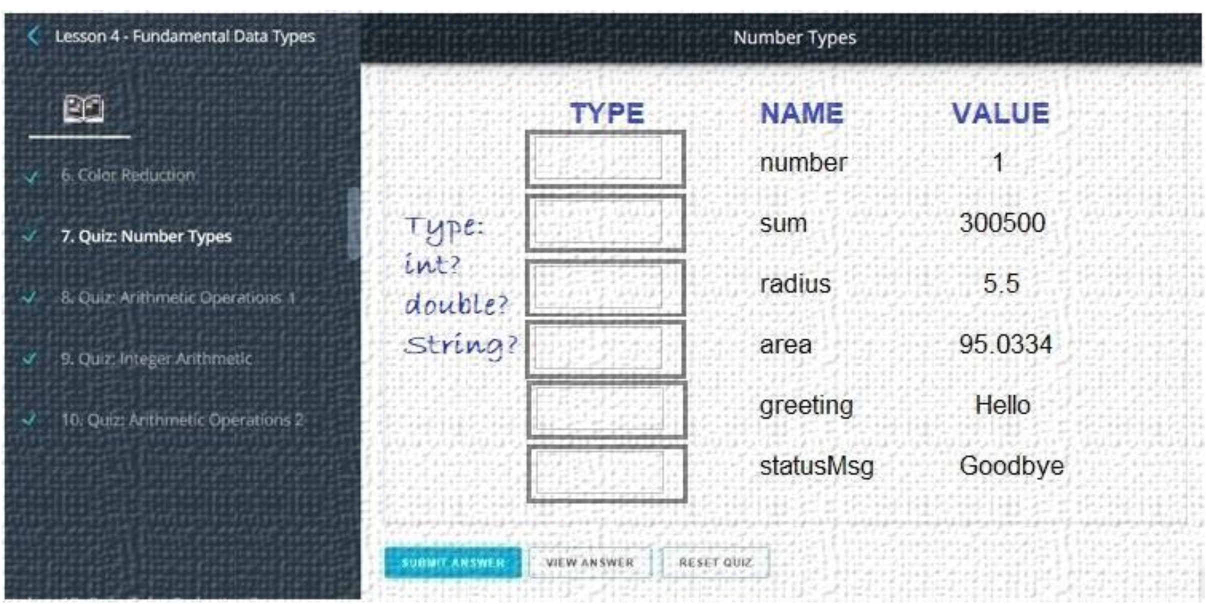

Figure 4-30. First problem in a sequence

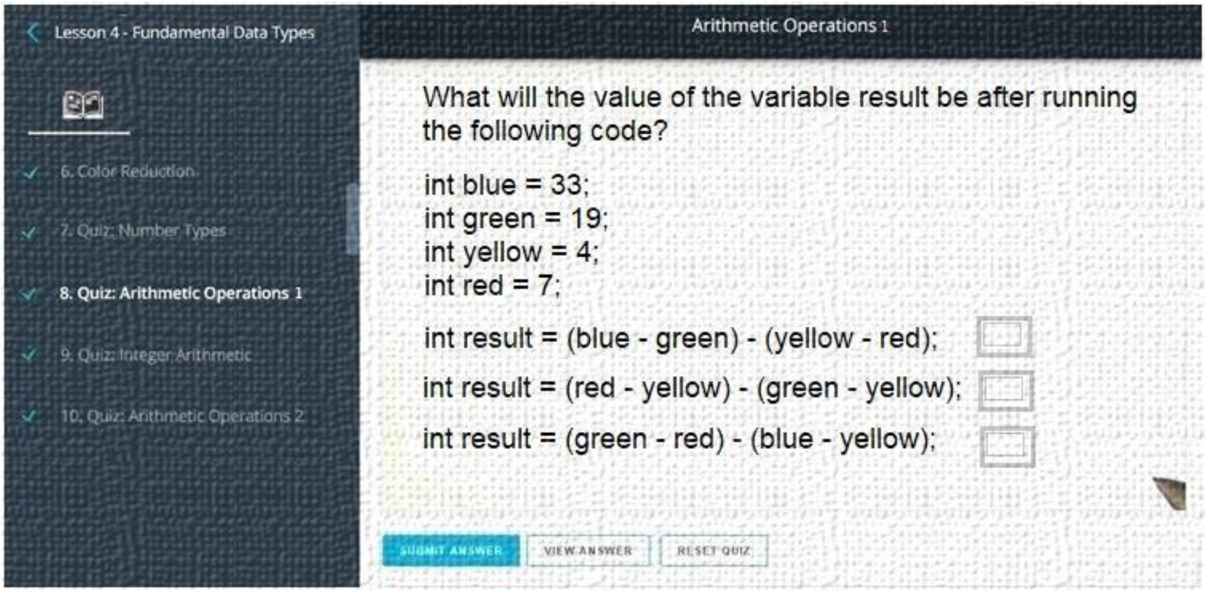

Figure 4-31. Second problem in a sequence

Related Patterns

Varied Problems is often implemented with Practice Consistency and Diminishing Coaching.

Supporting Research

1. Hilbert, T. S., Renkl, A., Schworm, S., Kessler, S., & Reiss, K. (2008). Learning to teach with worked-out examples: A computer-based learning environment for teachers. *Journal of Computer Assisted Learning, 24*(4), 316-332.

2. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

3. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models*. New York, NY: Routledge.

4. Salden, R. J. C. M., Koedinger, K. R., Renkl, A., Aleven, V., McLaren, B. M. (2010). Accounting for beneficial effects of worked examples in tutored problem solving. *Educational Psychology Review, 22*(4), 379-392.

5. Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251-296.

6. van Merrienboer, J. J. G. (2012). Variability of practice. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 3389-3390). Heidelberg, Germany: Springer-Verlag.

Watch Me Design Pattern

Pattern Name

Watch Me

Also Known As

See What I Can Do

Category

Integration

Context

Instruction should encourage learners to demonstrate their newly acquired knowledge and skills.

Problem

While animation, games, and multimedia may grab attention, these are not the motivational factors of instructional products. In other words, those interactive media have a short-term effect on motivation.

Forces

Learning is promoted when learners demonstrate how to solve a problem or perform a task. Also, the most inspiring activity is when learners can observe their own learning progress.

Solution

Carefully designed instruction should increase learner motivation. One of the most motivating event is when learners realize they can accomplish a task or solve a problem that they could not perform before. Learners deeply desire to demonstrate their newly acquired skills when they obtain new abilities. Thus, instruction should give a chance for learners to apply their ideas, demonstrate their solutions, and receive feedback from the instructor. Other than that, educational games, for instance, presenting learners with the increasing skill level in which they can observe their own learning progress.

Consequences

When learners are able to demonstrate improvement in skills, they have incorporated new knowledge into their lives.

Learning Scenario

Figure 4-49 illustrates the metamodel of the Watch Me learning scenario.

Examples

Demonstration is an opportunity for learners to defend ideas and publicize their solutions as in Figure 4-32. Providing social learning environments such as class forums is important as learners are able to see other points of view. After learners solve a problem or perform a task, they should receive feedback from the instructor as in Figure 4-33. Providing some explanations could guide learners during learning.

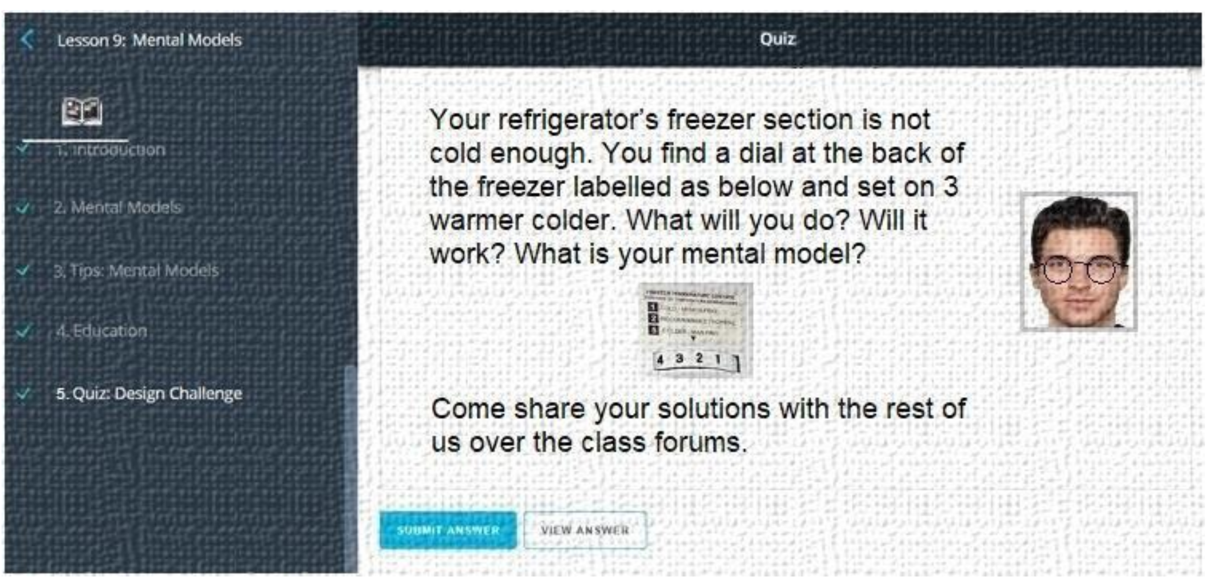

Figure 4-32. Demonstrate a task or solve a problem

Figure 4-33. Receive feedback

Related Patterns

Watch Me is often implemented with Reflection and Creation.

Supporting Research

1. Hilbert, T. S., Renkl, A., Schworm, S., Kessler, S., & Reiss, K. (2008). Learning to teach with worked-out examples: A computer-based learning environment for teachers. Journal of Computer Assisted Learning, 24(4), 316-332.

2. Merrill, M. D. (2002). First principles of instruction. Educational Technology Research and Development, 50(3), 43-59.

3. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). Instructional-design theories and models. New York, NY: Routledge.

4. Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. Educational Psychology Review, 10(3), 251-296.

5. van Merrienboer, J. J. G. (2012). Variability of practice. In N. M. Seel (Ed.), Encyclopedia of the Sciences of Learning (pp. 3389-3390). Heidelberg, Germany: Springer-Verlag.

Reflection Design Pattern

Pattern Name

Reflection

Also Known As

Reflective Thinking

Category

Integration

Context

Instruction should allow learners to reflect on what they have learned and share with peers.

Problem

Too often instruction requires learners to perform a task or solve a problem. Reflection is another important component of instruction, giving a chance for learners to review their learning processes.

Forces

Instead of just turning in their task performance or problem solutions to the instructor, effective instruction requires learners to reflect on and share with peers.

Solution

Reflection is a critical thinking process, making judgments about what has happened through the process of analyzing. In order to support reflective thinking, open online courses could provide an opportunity for learners to reflect after completing the lessons in each unit. During explorations, it is important to provide feedback to guide learners' thought processes. Providing authentic tasks that involve ill-structured data could encourage reflective thinking among learners. Also, learning environments that are flexible could prompt learners to discover what they believe is important.

Consequences

When learners are able to reflect on their new knowledge, they have integrated instruction into their lives.

Learning Scenario

Figure 4-50 illustrates the metamodel of the Reflection learning scenario.

Examples

Reflection is a significant activity in problem-solving models for collaborative problem solving. Figure 4-34 shows a reflection task and learners are required to share their reflective thinking with peers over the forums. By actively participating in reflective thinking, learners generally control and aware of their learning. Reflective thinking allows learners to bridge the gap assess between what they need to know and what they already know during the learning process.

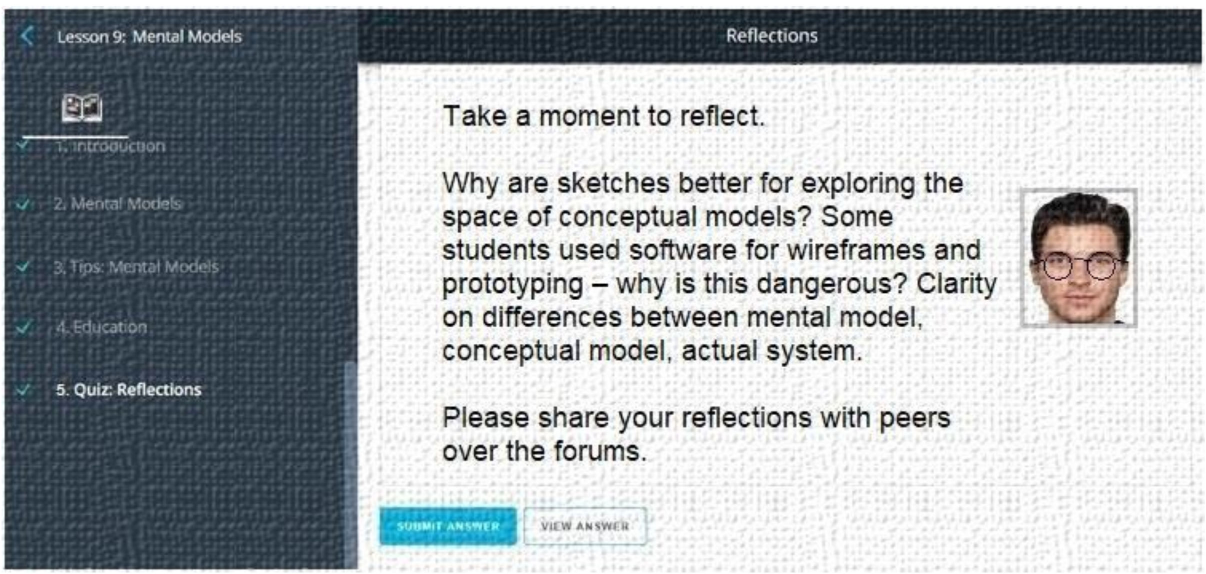

Figure 4-34. Reflective thinking task

Related Patterns

Reflection is often implemented with Watch Me and Creation.

Supporting Research

1. Merrill, M. D. (2002). First principles of instruction. Educational Technology Research and Development, 50(3), 43-59.

2. Moller, L., Huett, J. B., & Harvey, D. M. (2009). Learning and instructional technologies for the 21st century: Visions of the future. New York, NY: Springer.

3. Morrison, G. R., Ross, S. M., Kalman, H. K., & Kemp, J. E. (2013). Designing effective instruction. Hoboken, NJ: John Wiley & Sons.

4. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). Instructional-design theories and models. New York, NY: Routledge.

5. Retalis, S., Georgiakakis, P., & Dimitriadis, Y. (2006). Eliciting design patterns for e-learning systems. Computer Science Education, 16(2), 105-118.

Creation Design Pattern

Pattern Name

Creation

Also Known As

Invention

Category

Integration

Context

Instruction should provide an opportunity for learners to create, explore, and invent personal ways to apply their newly acquired skills.

Problem

Most instruction focuses on applying a procedure and analyzing how the parts relate to one another. However, creating individual adaptations of the new ability is one of the most effective instructions.

Forces

Encouraging learners to incorporate the new knowledge or skill into their everyday life.

Solution

Creating requires learners to put all of the pieces together in order to form a functional whole. In other words, creating allows learners to reorganize elements into a new structure or pattern. This mental function is the most difficult process in the revised taxonomy of the cognitive domain. For instance, learners will be able to create a learning portfolio as part of the learning objectives. Another learning objective is learners will be able to design efficient project workflow.

Consequences

Learning is promoted when a learner moves beyond the instructional environment, and modifies the new knowledge and skill to make it personal.

Learning Scenario

Figure 4-51 illustrates the metamodel of the Creation learning scenario.

Examples

Creating is the most complex level in the revised Bloom's taxonomy. This level depends on the analysis as a fundamental process, which similar to the distinction between critical thinking and creative thinking. Figure 4-35 shows the most complex type of cognitive thinking – creating task. To reiterate, creating is putting parts together to structure a functional whole or rearrange parts in a new and personal way. This process can be achieved through generating, planning, and producing elements into a new structure or pattern. In this quiz, learners are asked to plan their action on how they would proceed to develop a user interface for a software application.

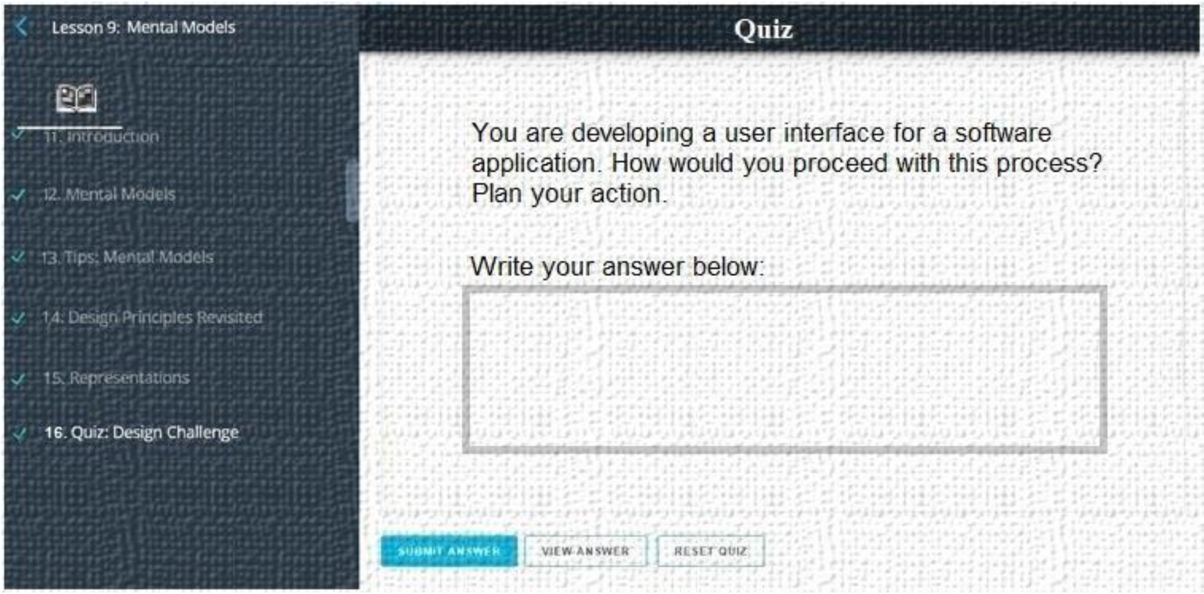

Figure 4-35. Creating task

Related Patterns

Creation is often implemented with Watch Me and Reflection.

Supporting Research

1. Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of educational objectives*. Boston, MA: Allyn & Bacon.

2. Bloom, B. S., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals*. New York, NY: Longmans.

3. Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development,* 50(3), 43-59.

4. Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models*. New York, NY: Routledge.

Structure of Open Online Learning Design Patterns

The practicality of design patterns is important since the goal of design patterns is the description of reusable solutions to recurring problems. Each instructional design pattern is not isolated, but it is interrelated to other design patterns in the catalog. Figure 4-36 depicts these relationships, for instance, “Show Task” is part of a dimension of patterns for “Problem” that includes “Task Level” and “Problem Progression.” In solving real-world problems, learning is promoted when learners are firstly given an overview of the whole task, often includes the learning objective and benefits to indicate what the learners will be able to do after completing a course or a module (Merrill, 2002). The “Show Task” design pattern captures a fundamental aspect of the task-centered learning experience. However, it is still incomplete to create a working blueprint for a comprehensive task-centered learning. Instead, just like other established design patterns, this design pattern can only make sense when it is used with the other related design patterns. In this case, “Show Task” should be used together with “Task Level” and “Program Progression.”

Recommendation for Practice

In getting started with a MOOC, the instructional designer needs usable mechanisms to activate prior knowledge of the learner and get them familiar with the new learning environment. The design scenarios as follows,

Name: Getting started in a computer science MOOC.

Context: Introduction to Human Computer Interaction (HCI) is an introductory course on HCI, covering the principles, techniques, and open areas of development in HCI.

Challenge: A first time learner enrolled in an intermediate computer science MOOC. This course does not have significant prerequisites before participation. The timeline for the course is approximately 16 weeks.

Patterns Used: Show Task, Task Level, Problem Progression, Prior Knowledge, Existing Experience, Structure

Proposed Solution: An introduction to the course topics, “Prior Knowledge” will present the learner with a short audio/slide presentation about the basic concepts of Humans, Computers, and Interaction. “Structure” will direct the learner to the advance organizer about HCI in order to provide learners with a conceptual model that can facilitate the acquisition of problem solving. “Existing Experience” is where the learner will reflect about Interacting and Interfaces covered in the introduction. “Show Task” will show a new whole task to the learner. After a brief explanation of the first lesson, “Task Level” will present topic components. Learners can click on the first quiz. The learner will solve a progression of problems that are explicitly compared with each other through “Problem Progression.”

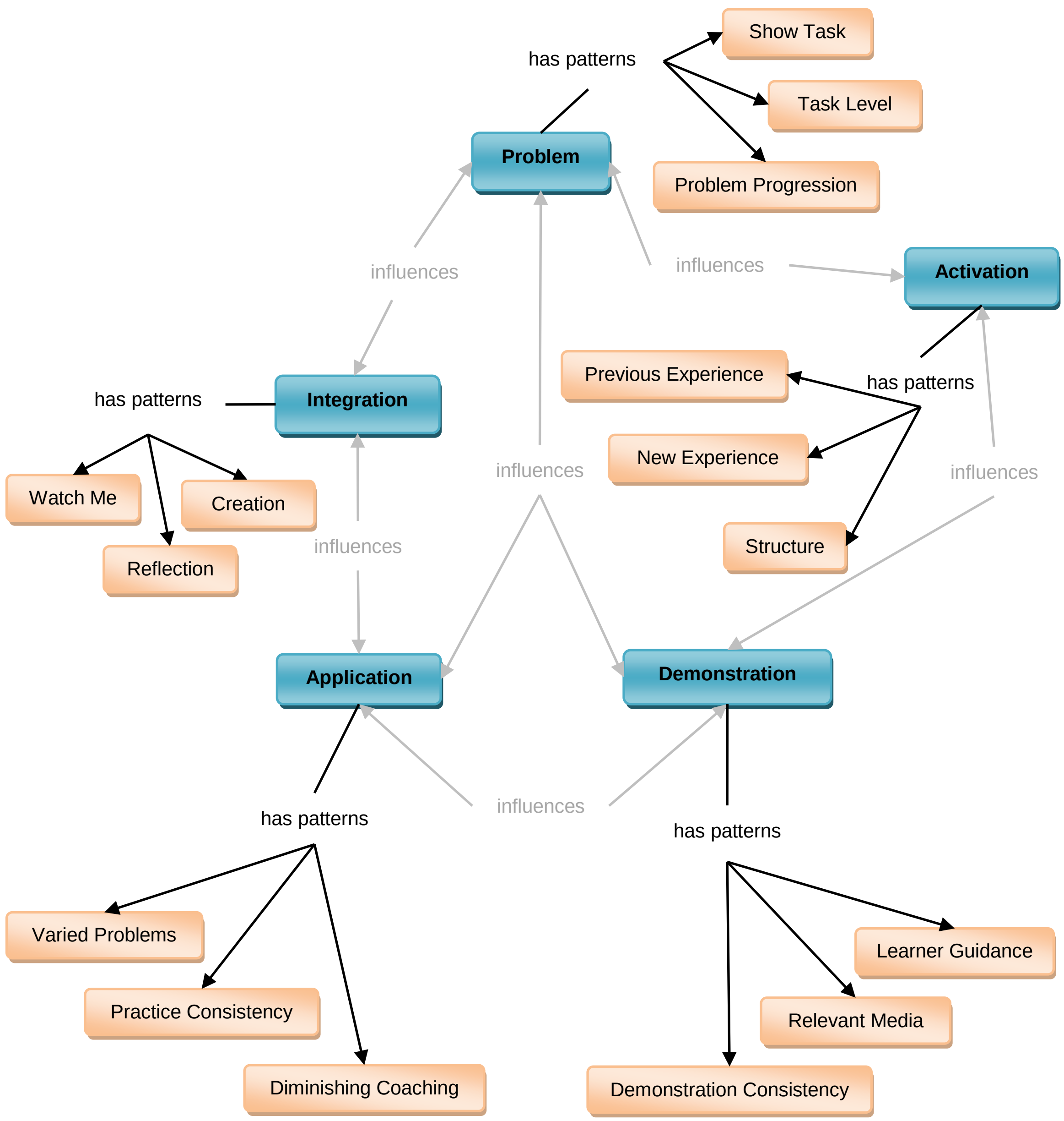

Figure 4-36. Open online learning design pattern relationships

Summary

This study proposed five dimensions of design patterns with 15 design patterns that captured and presented solutions to problems in which the instructional designers can use when designing open online learning for computer science courses. The catalog of design patterns was developed from the self-observation, expert interview, analysis of the functionality of computer science MOOCs, review of the literature on pedagogical strategies, and learn from existing published patterns in other related areas. Merrill’s First Principles of Instruction were used to organize the catalog of open online learning design patterns. This study used a template that was modified from the Gamma et al. (1995) and Alexander (1979) pattern structures to describe and organize design patterns. Each design pattern was named, explained and described systematically. The full list of design patterns was presented in this chapter that indicated the pattern name, also known as, category, context, problem, forces, solution, consequences, learning scenario, examples, related patterns, and references.

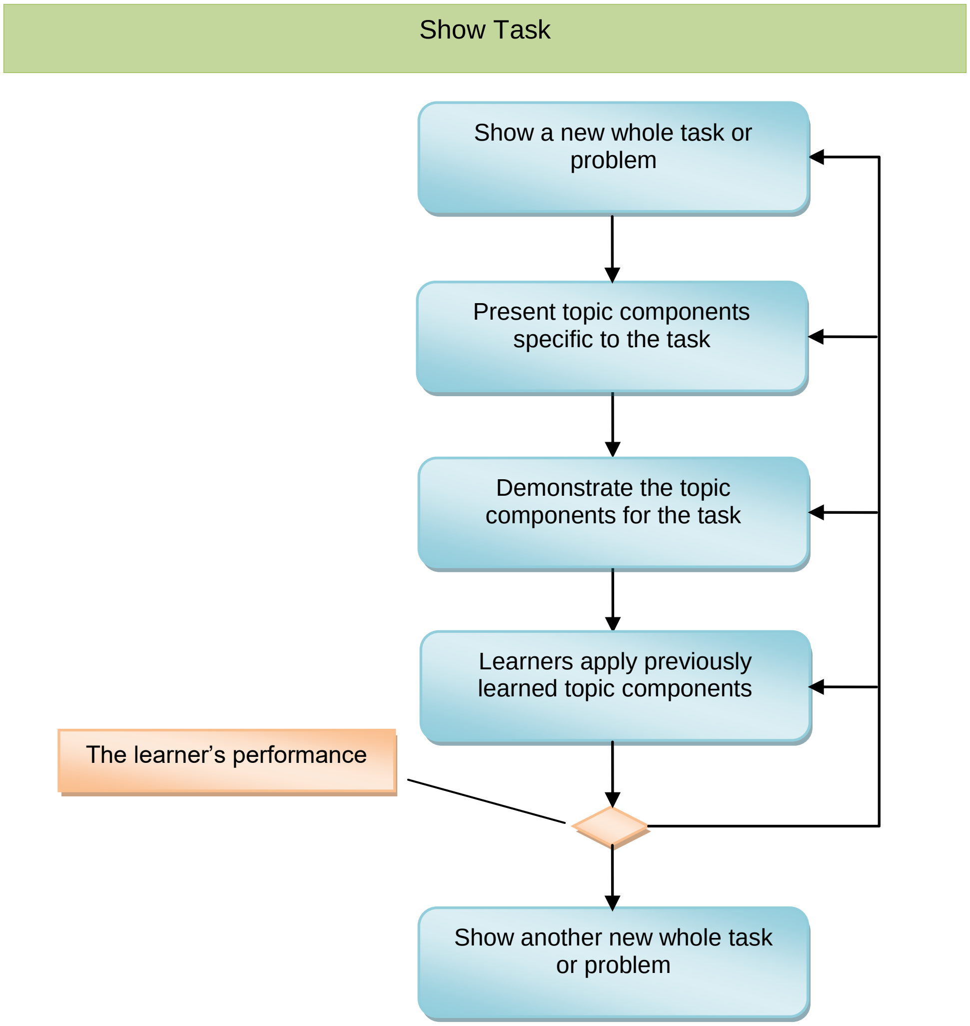

Figure 4-37. The metamodel of the Show Task learning scenario

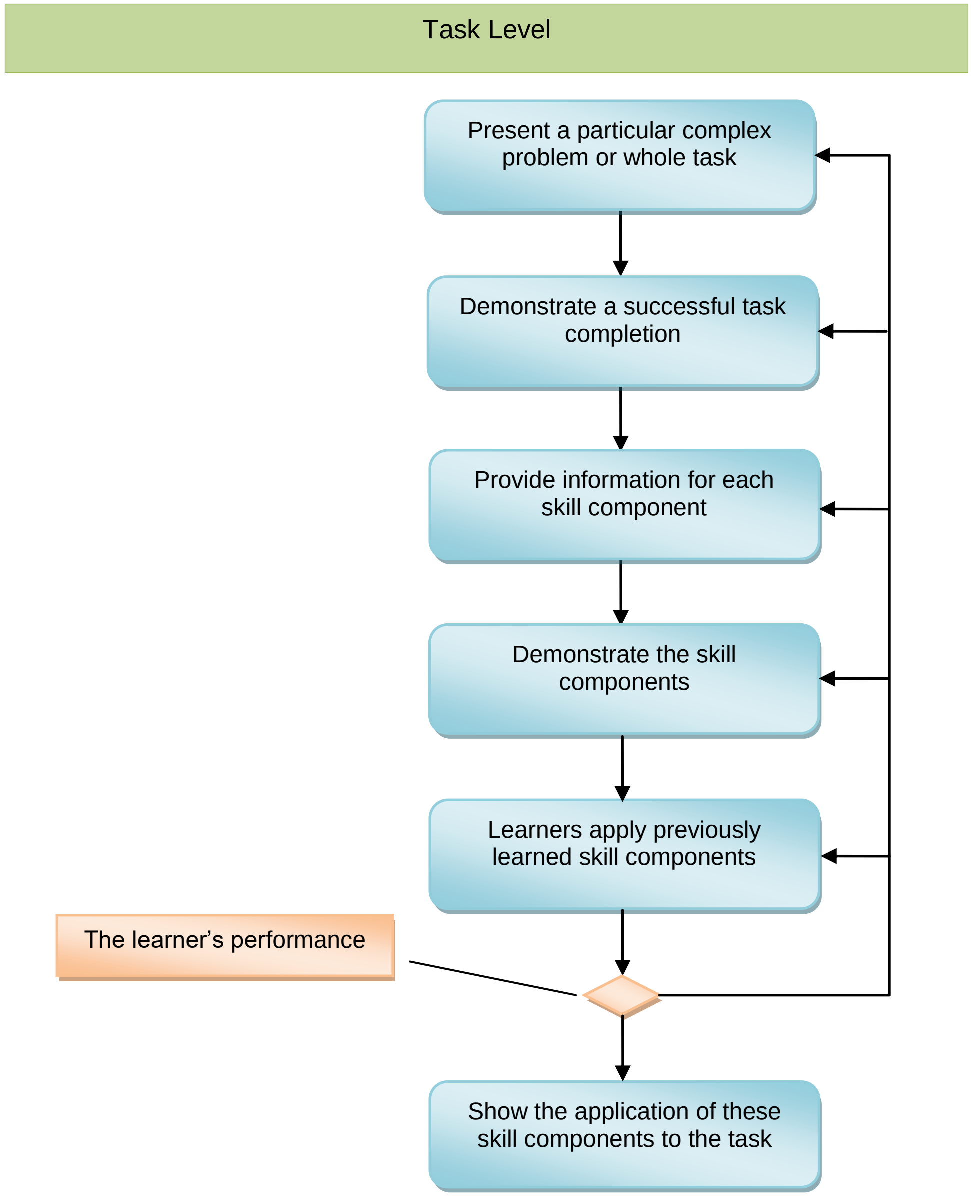

Figure 4-38. The metamodel of the Task Level learning scenario

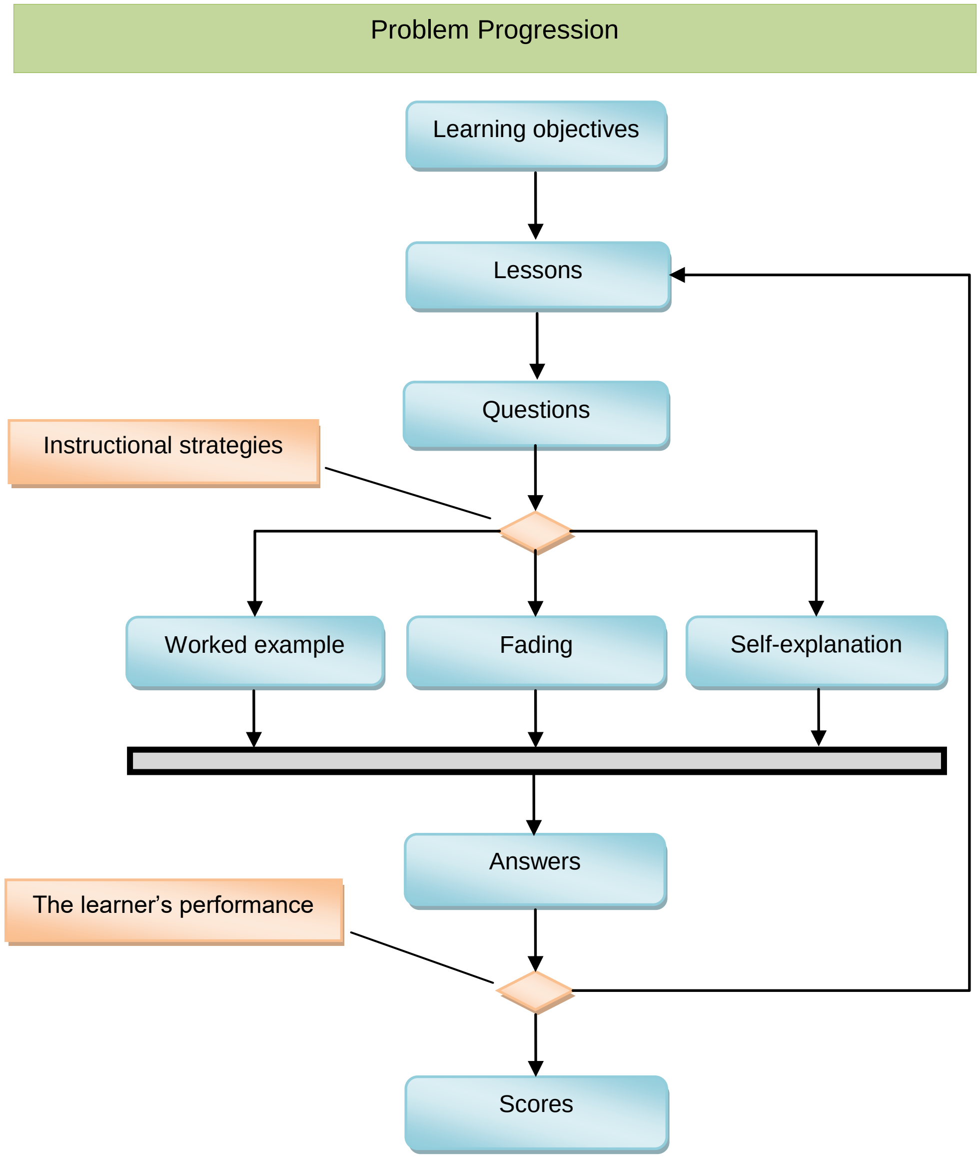

Figure 4-39. The metamodel of the Problem Progression learning scenario

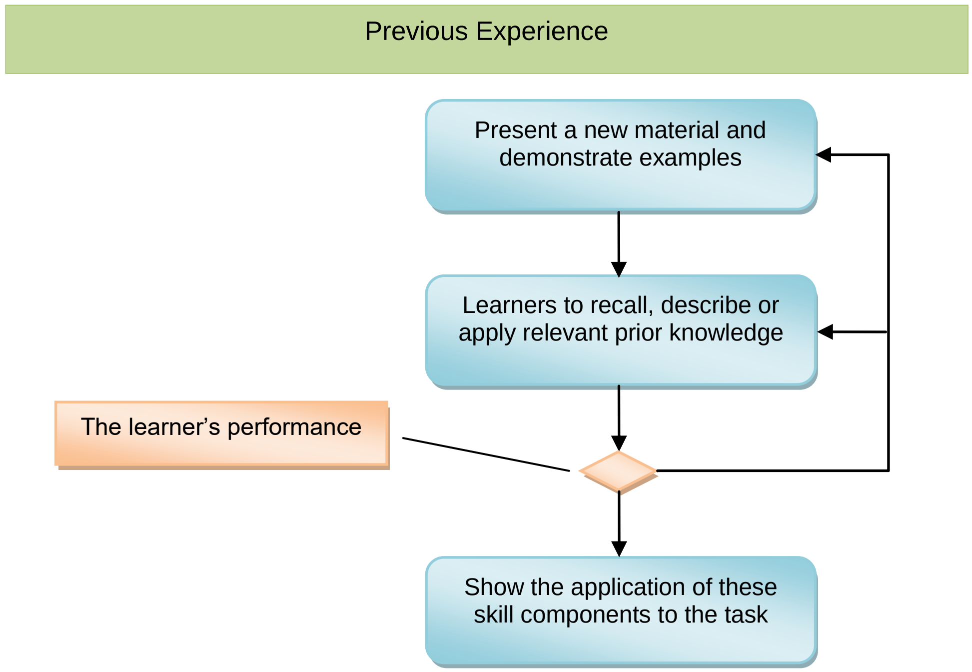

Figure 4-40. The metamodel of the Previous Experience learning scenario

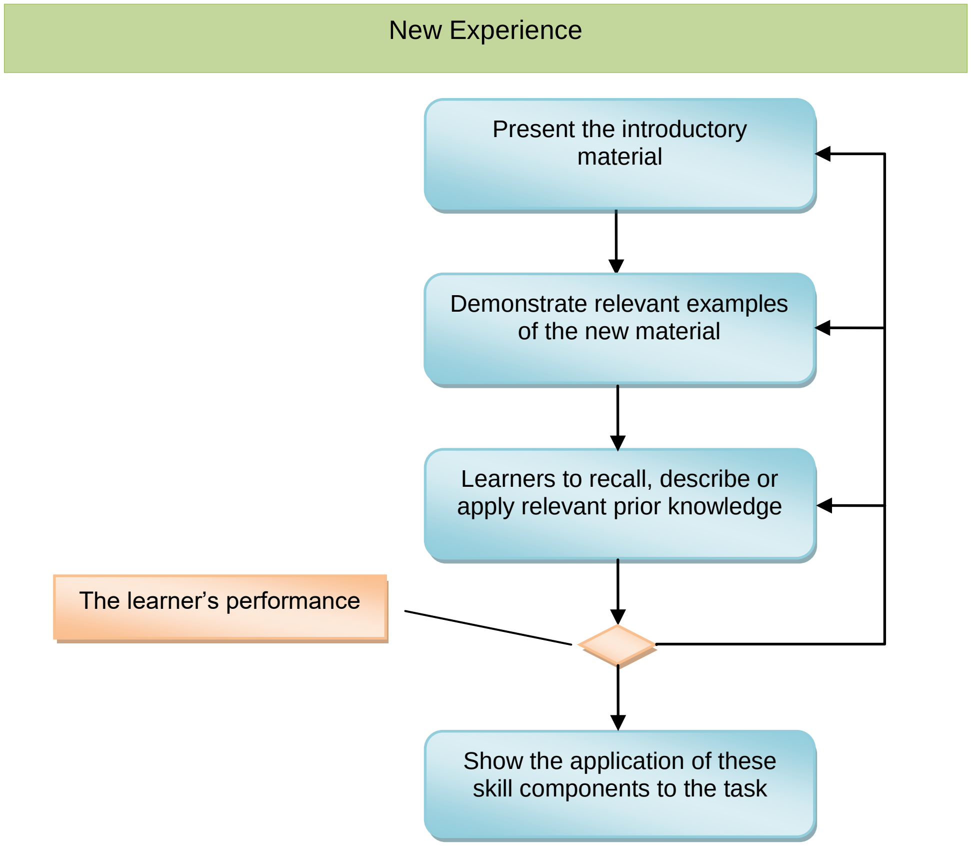

Figure 4-41. The metamodel of the New Experience learning scenario

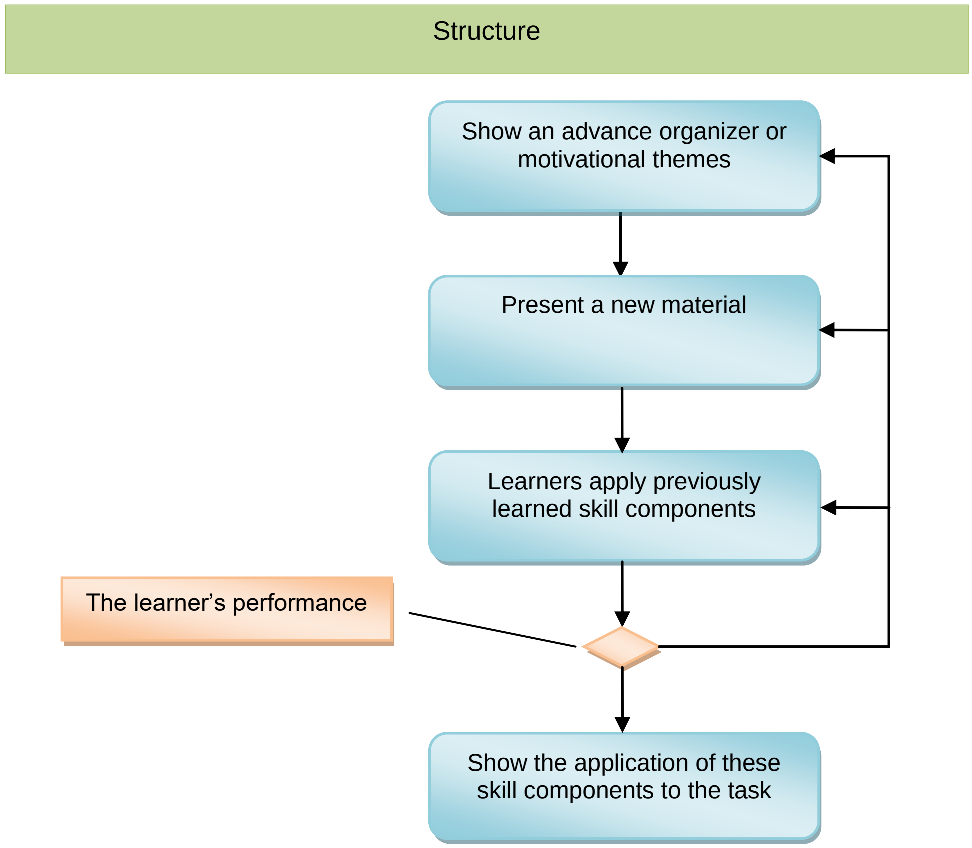

Figure 4-42. The metamodel of the Structure learning scenario

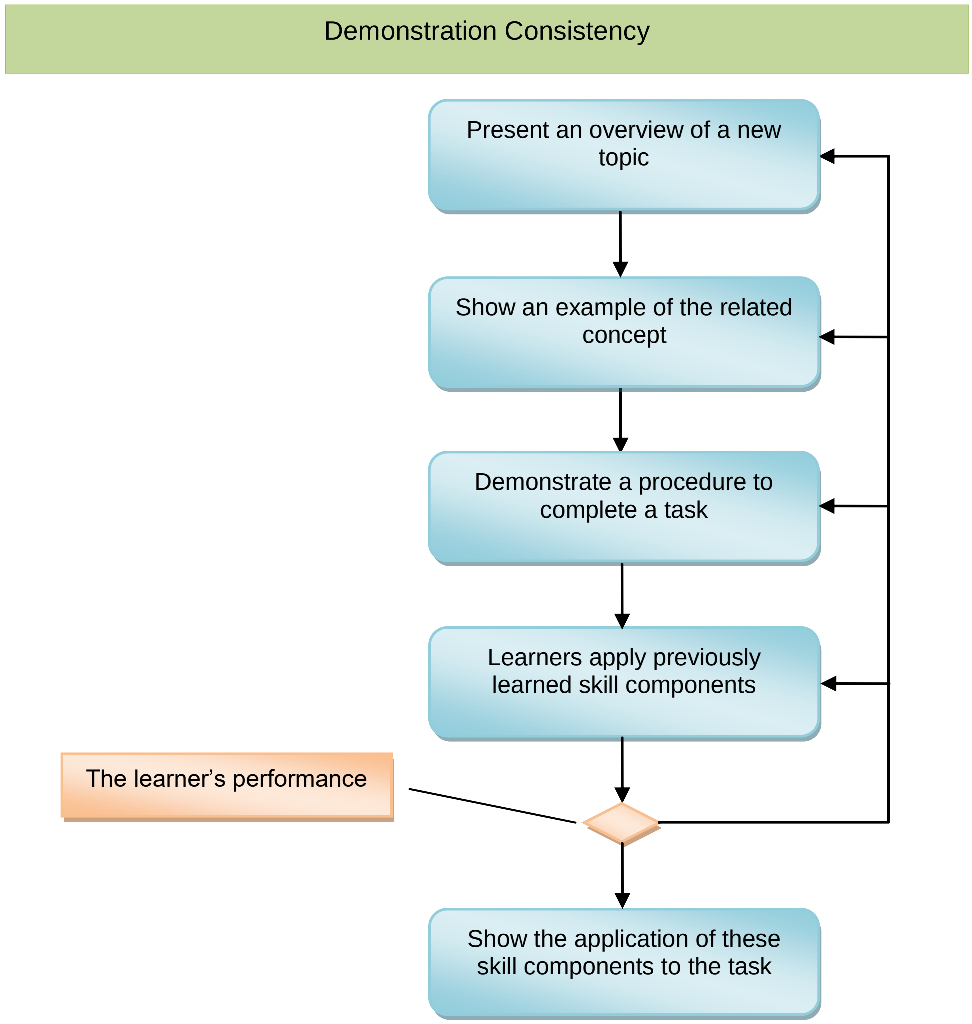

Figure 4-43. The metamodel of the Demonstration Consistency learning scenario

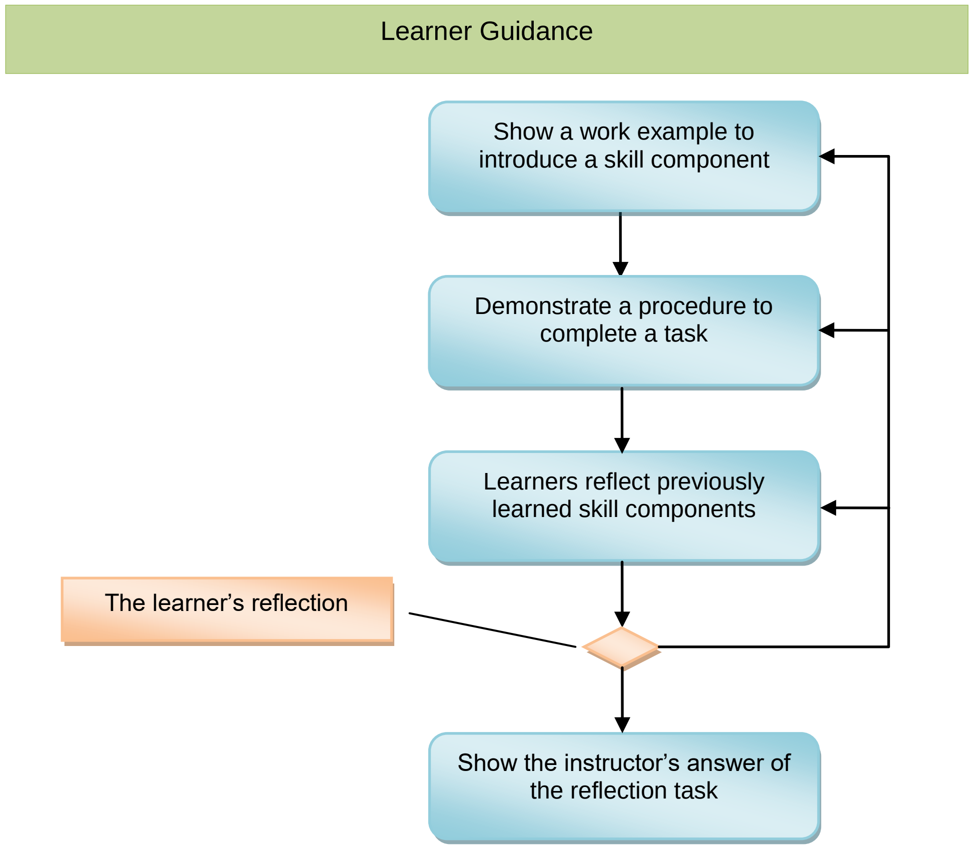

Figure 4-44. The metamodel of the Learner Guidance learning scenario

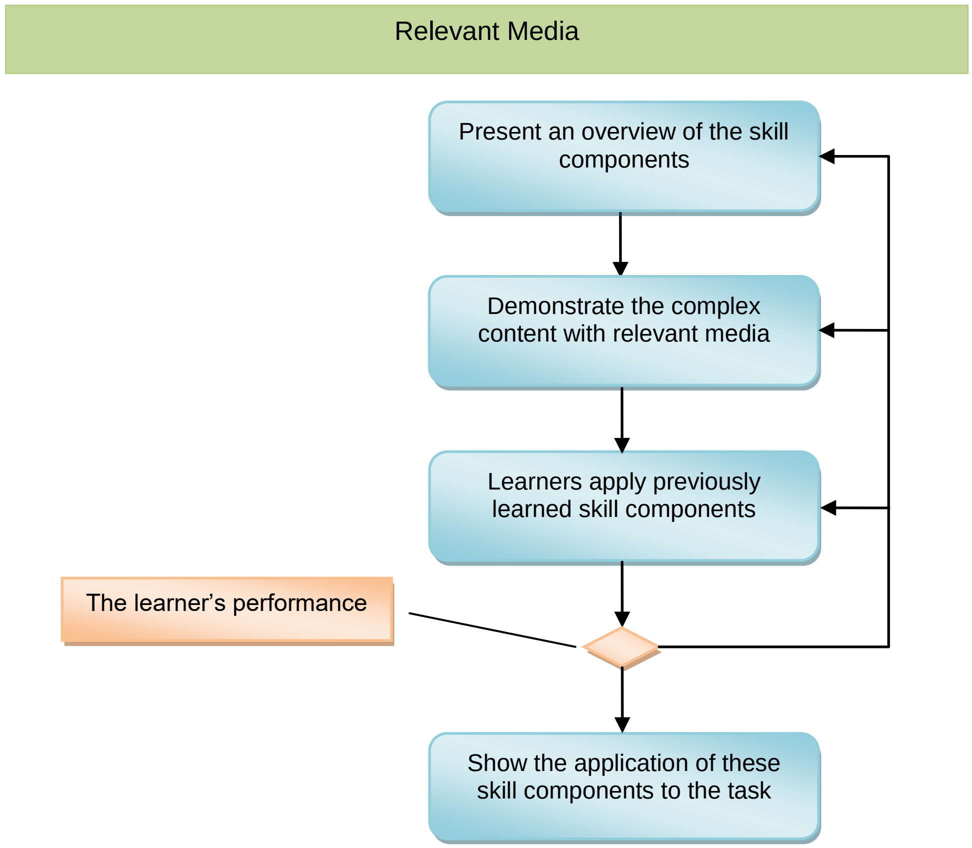

Figure 4-45. The metamodel of the Relevant Media learning scenario

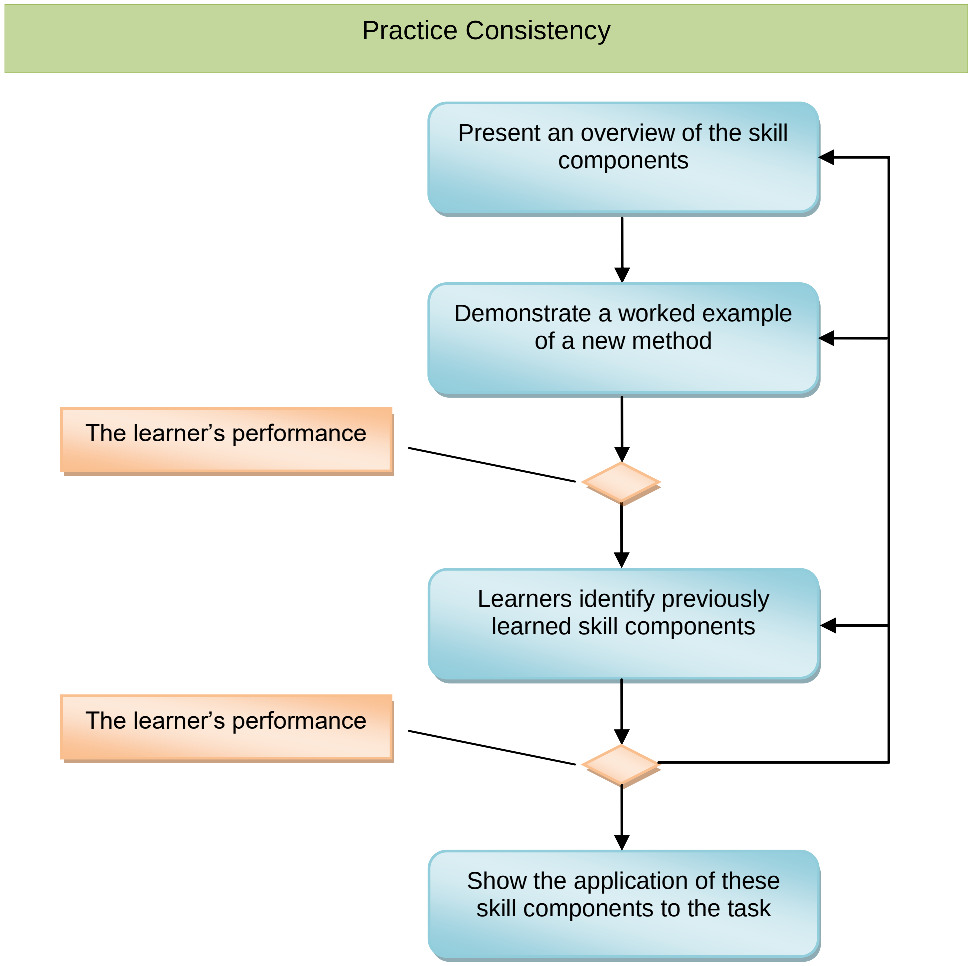

Figure 4-46. The metamodel of the Practice Consistency learning scenario

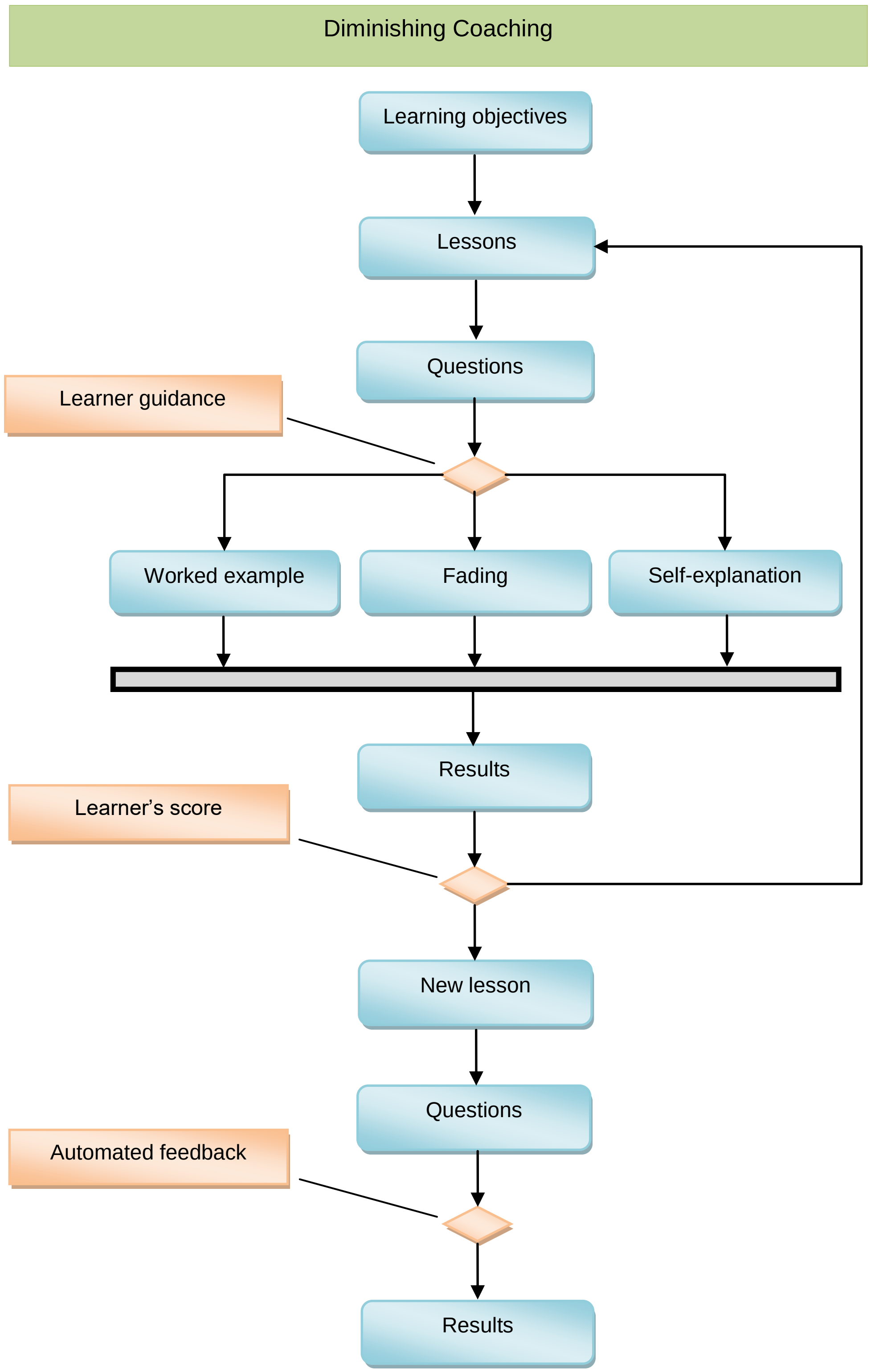

Figure 4-47. The metamodel of the Diminishing Coaching learning scenario

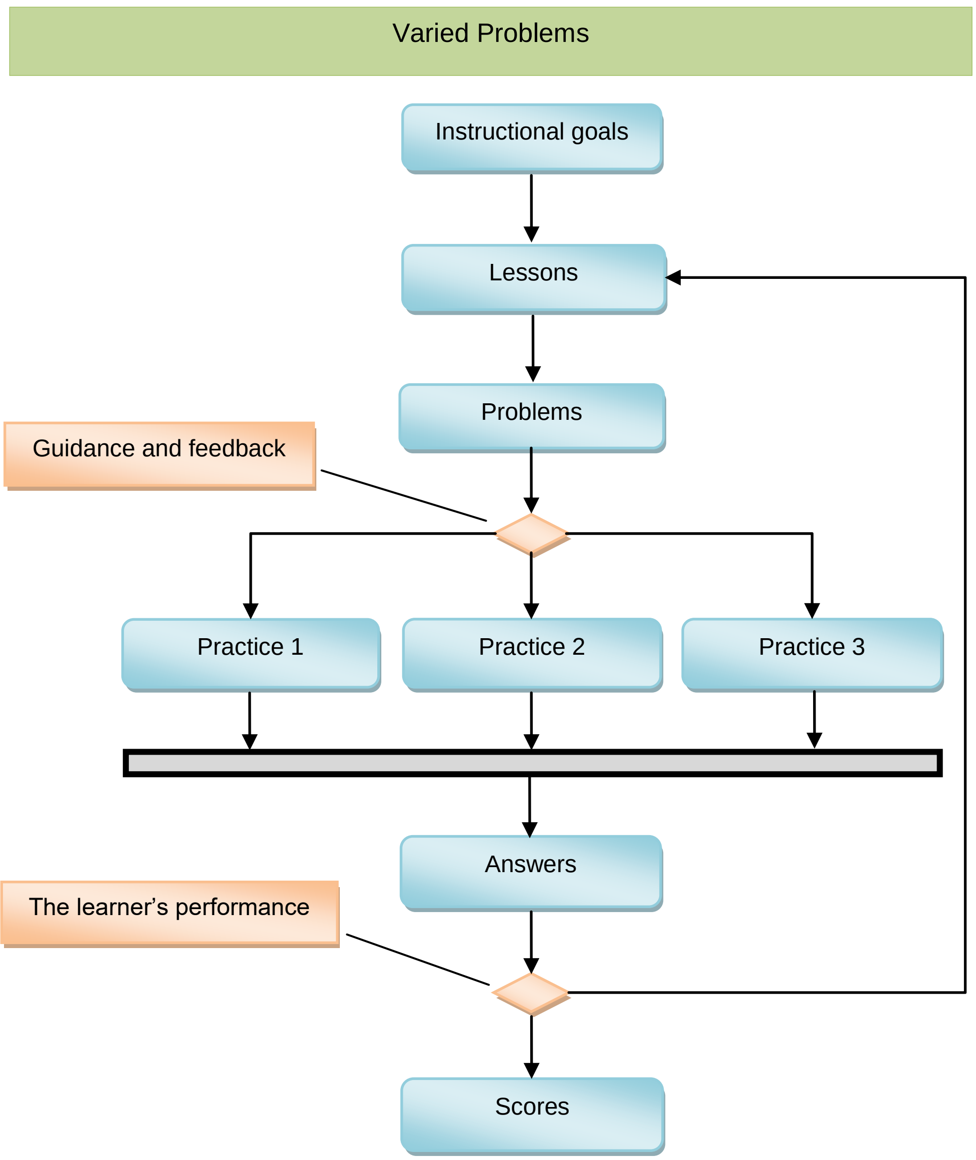

Figure 4-48. The metamodel of the Varied Problems learning scenario

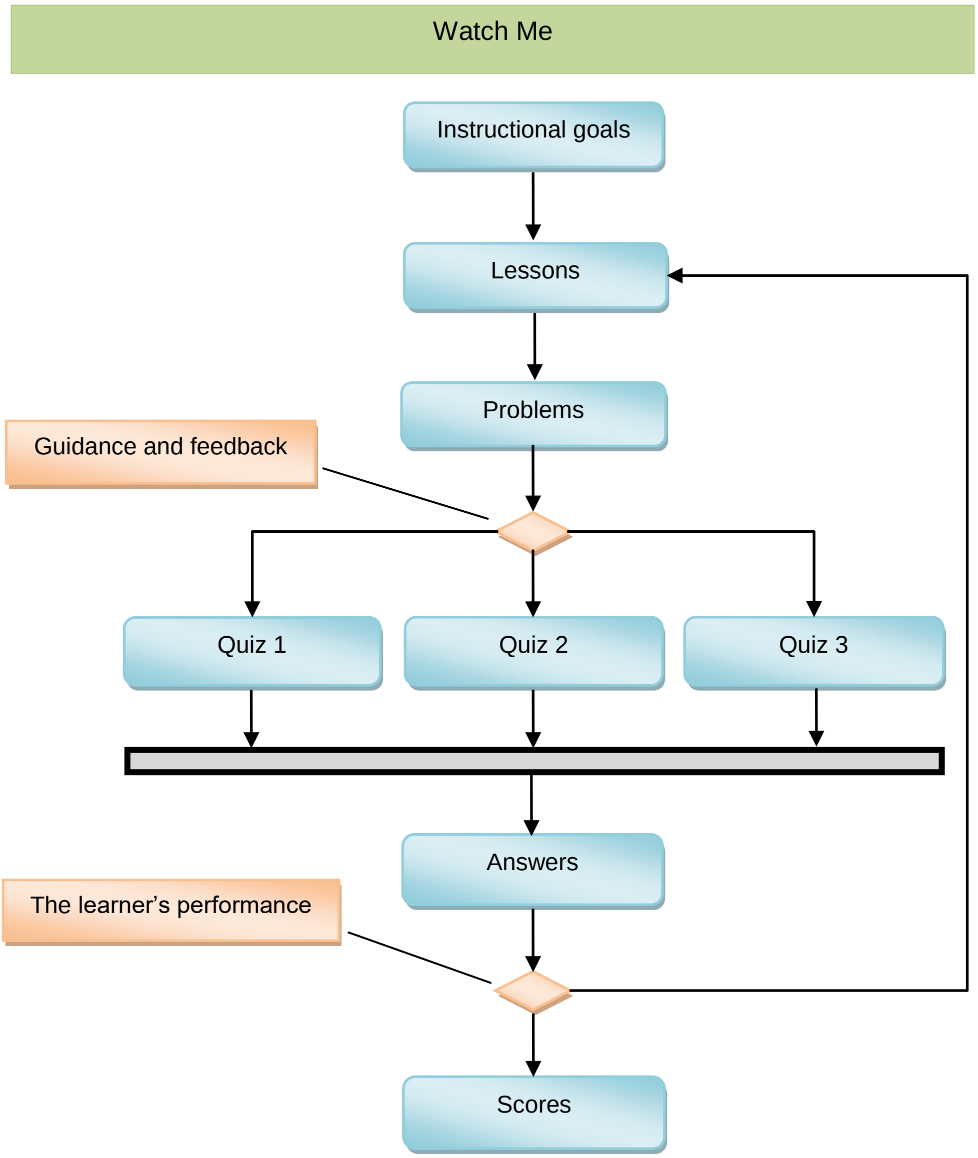

Figure 4-49. The metamodel of the Watch Me learning scenario

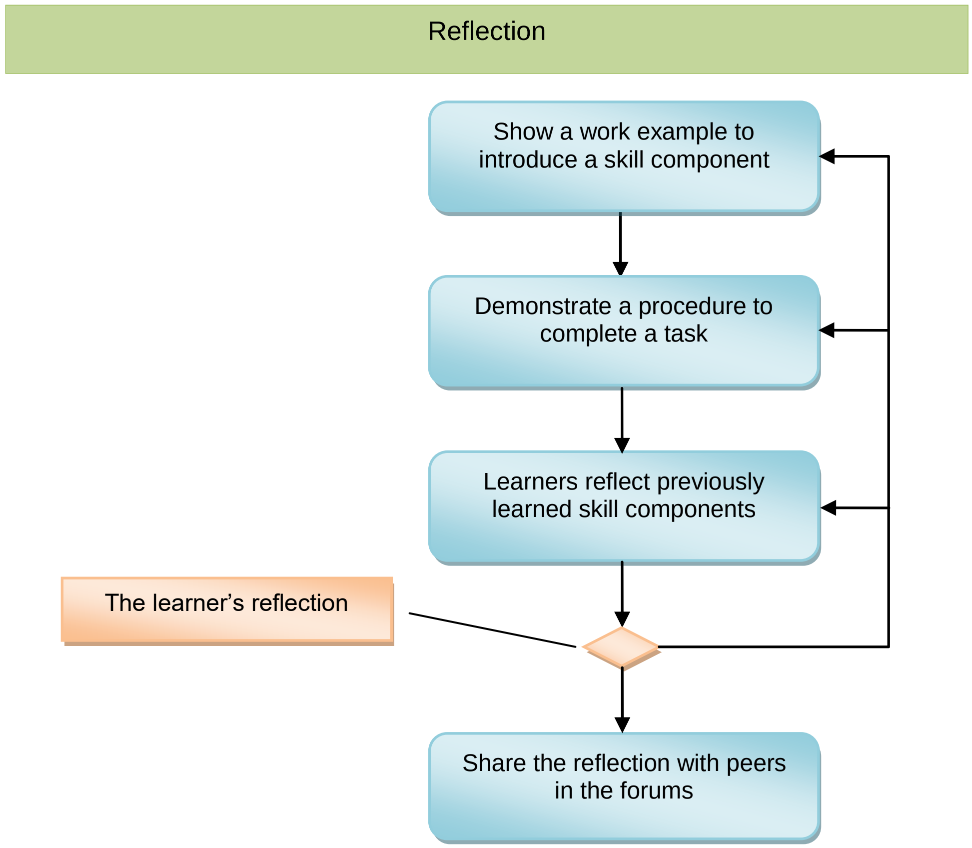

Figure 4-50. The metamodel of the Reflection learning scenario

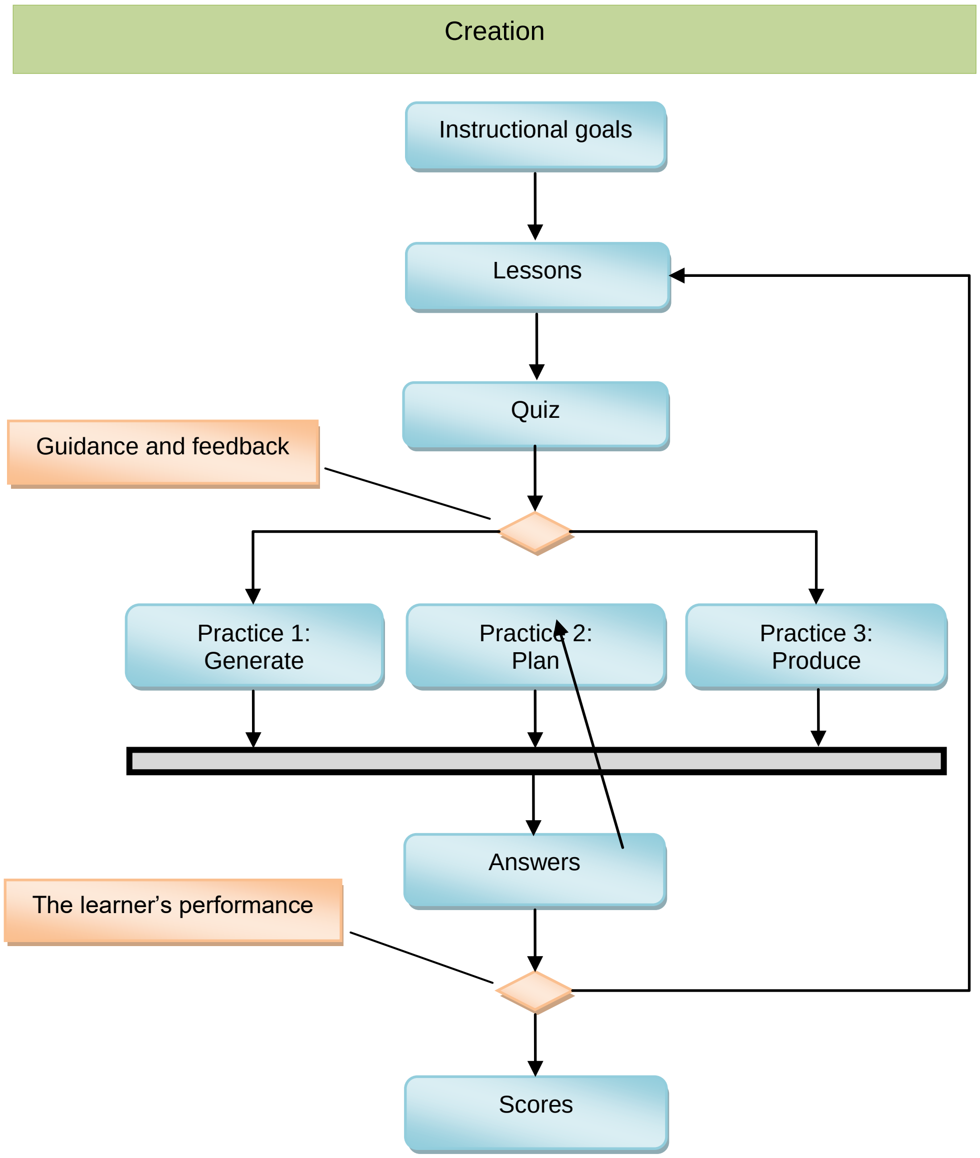

Figure 4-51. The metamodel of the Creation learning scenario

CHAPTER 5
DISCUSSION

Massive Open Online Courses (MOOCs) have revolutionized higher education by delivering high quality content to a large amount of learners via the Internet (Staubitz, Petrick, Bauer, Renz, & Meinel, 2016). All of the leading MOOC providers such as Coursera, edX, and Udacity have built their courses through partnerships with prominent universities, for instance Massachusetts Institute of Technology, Harvard University, and Stanford University. Institutions around the world are increasingly looking for ways in blending MOOC content and materials into their on-campus teaching or hosting their own MOOCs (Bonk, Lee, Reeves, & Reynolds, 2015). Existing research on major MOOC providers has found that more than half of total enrollment was in computer science courses (Straumsheim, 2015). Identifying the key design features for these computer science MOOCs is somehow difficult as MOOCs depend on an evolving set of practices. Hence, there is a demand for a more structured method for documenting and describing best practices in designing open online courses. To address this gap in the literature, this study sought to answer the following research questions:

1. To what extent do the design patterns exist within the Massive Open Online Courses in computer science?
2. How is a catalog of design patterns for open online learning constructed?

The first research question of this study was answered through the design pattern mining. In this study, design patterns of MOOCs were mined through five methods: (1) Self-observation, (2) Expert interview, (3) Analysis of the functionality of computer science MOOCs, (4) Review of the literature on pedagogical strategies, and

(5) Learn from existing published patterns in other related areas. The second research question was answered through the design pattern writing.

Discussion of Findings

The results presented in Chapter 4 address a qualitative content analysis, from self-observation to existing published patterns in other related areas, as well as the catalog of design patterns. The discussion provided in this chapter will interpret the findings as they are relevant to the research questions, and also the theoretical framework employed in their pursuit.

Use of Online Affordances

Learner-to-learner interaction

The findings of this study indicated that a learner-to-learner interaction within MOOCs occur through peer assessment and discussion forums. The findings suggested that peer assessment could enhance learners' understanding and knowledge by enabling them to evaluate the work of peers. Learners could also develop critical thinking skills through the process of assessing other learners. Peer assessment has been successfully implemented in traditional classrooms and regular online learning (van Zundert, Sluijsmans, & van Merrienboer, 2010). However, more evidence is needed to determine the successful implementation of peer assessment in MOOCs (Staubitz, Petrick, Bauer, Renz, & Meinel, 2016).

It is not surprising that assigning learners randomly for peer feedback can be complicated as some learners may not have the ability or knowledge in giving an accurate assessment or fair judgement to a peer's work (Staubitz et al., 2016). Also, it is extremely difficult to create a good scoring rubric for learners to assess other's work. In the analysis of instructional design quality of 76 randomly selected MOOCs, Margaryan et al. (2015), found that there were no collaborative activities for 68 MOOCs. Collective knowledge in MOOCs refers to the extent to which the learning activities require learners learn from each other. Instead of merely consuming knowledge, learners should contribute to collective knowledge and build on the other peers' work (Margaryan et al., 2015).

In contrast to the face-to-face classroom where learners are expected to interact before, during, and at the end of each lesson, online learners and instructors are represented by on-screen text. The text-based interaction occurs in the online learning community can be misinterpreted by learners due to the lack of visual expressiveness (McInnerney & Roberts, 2004). Discussion forums are spaces where MOOC learners from all over the world ask for help, comment on the content of the course, post questions, provide suggestions, reflect on what have been learned, and share ideas. Learners rely on each other to respond to questions or comments when instructors offer no moderation in the forums.

Collaboration and social interaction is essential for successful participation in online learning tasks. Hence, this study proposed the use of discussion forum in practice consistency and learner guidance design patterns. Besides discussion forums for communication, one participant mentioned that learners can connect to one another in-person through Udacity Connect. Unfortunately, MOOCs are not always open as in the sense of Open Educational Resources (OER) since learners can only add Udacity Connect if they pay $99 a month.

Learner-to-content interaction

Statements from participants of this study would seem to imply that a learner-to-content interaction occurs through instructional videos. Most computer science MOOCs use videos for intros, outros, explanations, tutorials, quiz introductions, and quiz solutions. While interactive programming quizzes are used for the student self-assessment. These instructional video forms were proposed in the catalog of design patterns to establish a learner-to-content interaction. It is interesting to note that learners received automated feedback on most programming exercises and all other types of quizzes frequently. Automated grading options were provided for simple testing, for instance multiple-choice, true/false, and short answer questions. Learners should be encouraged to analyze, apply, assess, evaluate, solve, synthesize, and reflect on what they learn as they interact with the content (Khan, 2016). During the learner-to-content interaction, learners process the information once they access the learning materials, and transform it from short-term to long-term memory (Khan, 2016).

Some open platforms allow limited access to reuse their material without permission and others may restrict the reuse of material. One participant in this study informed that his computer science MOOC, titled Introduction to Human Computer Interaction, provided more open ended assignments for assessing student learning. Examples of open ended assignments are essay questions to analyze existing interface, as well as surveys and interviews with real people. Although automated grading tools work best with computer science courses, the assessment is difficult for written essays. Some MOOC providers may charge a range of fees, especially for the open ended assessment as they cannot be graded by an automated grader.

Grading and providing feedback on open ended assignments in MOOCs has been the topic of a number of recent articles. edX announced to use automated essay scoring for supporting the assessment of written work (Markoff, 2013). Automated essay scoring was discovered more than a decade ago, and can provide rapid feedback as reliable as those from human raters for different types of essays (Balfour, 2013). The tool can also help learners improve their writing by giving them categorical feedback. However, this grading mechanism would be available outside their MOOC environment. On the other hand, Coursera decided to use peer evaluation to assess open ended assignments, in which learners are taught on a particular scoring rubric for an assignment using practice essays prior to the peer review process (Balfour, 2013). It would be valuable to consider a design pattern for an automated essay grading tool in the future.

Learner-to-instructor interaction

Another important finding was learners who were enrolled in the Udacity's Nanodegree received personalized feedback from an instructor on their project or cumulative assessment at the end of the course. MOOCs are not as open as their name – Nanodegree is an online certification for entry-level programming and analyst positions that can be completed in less than a year for $200 a month. On the other hand, Udacity Connect provides face-to-face learning, interactive feedback, goal setting, group accountability, and monitoring that can be added to the Nanodegree program. These open platforms certainly cannot replace the formal and credit-based education, but can be used to make it more effective.

Low instructor involvement after the course starts was a major claim related to MOOCs (Balfour, 2013). One participant explained that they interact with learners through discussion forums and free online collaboration platforms that have been integrated into the MOOC. Moderating each individual post may become overwhelming due to the large number of comments and discussion posts. Thus, the discussion or comments were moderated and directed at all learners rather than to individuals. Another participant informed that they used paid teaching assistants to respond to each learner's comment or questions.

The teaching assistants were also responsible to identify common areas of concern by a number of learners, and respond to these comments and questions. Based on the findings of this study, to develop conceptual and deep learning, the intervention by subject matter experts were required in order to provide feedback, enlighten misconceptions or misunderstandings, and even clarify arguments (Memmel, Wolpers, Condotta, Niemann, & Schirru, 2010). It might make sense to address this critical learner-to-instructor interaction in the catalog of design patterns.

Content and Course Material

Based on the findings of this study, it was surprising to know that beta testing was not performed anymore before a MOOC was released. Beta testing is a great way to ensure the effectiveness of an online course, and one of the critical steps to uncover content errors, usability, software bugs, and level of user involvement (Sekhon & Hartley, 2014). Coursera for instance recruited beta testers to spot any errors before launch their courses (Coursera, 2016). Beta testers refer to learners who enroll a course for the first time, and they are provided with a list of questions to consider while reviewing a course. They have to provide invaluable feedback to course instructors after reviewing the online course content. As of March 2016, the Coursera's beta tester community is limited to those who have tested a computer science course. It would be wonderful if all MOOC providers would consider beta testing before they go live.

Alternatively, participants in this study mentioned they were more into peer reviewing scripts and partnering a professor with instructional designers who experts in doing online courses before the video production. It was interesting to note that one participant confirmed three to four cycles of learner evaluation were planned through the course to obtain learner feedback – before and after the course. As with any software engineering process, understanding learner requirements is significant to design and develop an effective MOOC. Furthermore, another participant indicated they encouraged learners to post any feedback to the instructors. The instructors and instructional designers of MOOCs then adapted or changed course materials as a result of the learner feedback.

Instructional Strategy and Learning Outcomes

As one participant pointed out, “I would say that the most important thing is actually a match between the instruction and the learning goals... as well as the assessments that are going to be used.” This statement would seem to correspond with the First Principles of Instruction by Merrill (2002), “Demonstration consistency: Learning is promoted when the demonstration is consistent with the learning goal.” (p. 47) and “Practice consistency: Learning is promoted when the practice is consistent with the learning goal.” (p. 49). It would be beneficial to address these principles in the catalog of design patterns.

While successful completion has been a subject of interest to researchers, understanding the factors influencing learning outcomes, particularly learning activities and teaching context are significant as they are important steps towards designing high quality open online courses. Participants in this study clearly indicated that providing immediate feedback and fostering learner community are among the most effective methods. Rapid feedback on computer-marked assignments can be extremely valuable for formative assessment, which allowing learners to determine if they understood the concepts covered in the MOOCs.

Knowledge Activation

One participant clarified an even more basic concern when responding to a question about knowledge activation. For him, activation is more than just requires learners to recall prior knowledge or provide relevant experience. He pointed out the importance of learning activities that can be designed to stimulate the development of the mental models and schemes. “So unit one is like the introduction part of the entire course.” Apparently, the first lesson in each unit is the introduction to the unit as a way to connect the lesson to other areas of the course material, as well as how learners can apply those in the real-world. “So we try to have them connect it out to something beyond the course.” Learners were also asked to recall what they learned in the previous lesson. “So it kind of half set aside places where we’re talking about the content instead of teaching the content.” Again, these statements would seem to reflect the First Principles of Instruction by Merrill (2002), “Previous experience: Learning is promoted when learners are directed to recall, relate, describe, or apply knowledge from relevant past experience that can be used as a foundation for the new knowledge” (p. 46).

According to Sandeen (2013), only 10% of the learners who enroll in the prominent MOOCs actually complete the course. Factors influencing learners’ motivation have been explored for many years (Barak, Wateed, & Haick, 2016). The result of this study was not surprising, since it suggested that those who lost interest in the MOOC decided to drop out. As one participant mentioned, “So the only ones who are taking the course are the ones who are interested in the course. There aren’t students who take it because they need that credit." A student run review set is where learners give reviews of the courses in the program and it is publicly available. Based on the review, one participant considered two possible explanations why learners enrolled in his course.

First, the motivation to learn was based on their previous successful experience – they took his earlier courses and they liked him, so they just wanted to take another course with him. Barak et al. (2016) refers this intrinsic motivation to learn as "... inherent gratification prompted by the feeling that learning is interesting and enjoyable" (p. 50). Second, the motivation to learn was based on their desire to stay updated and informed about the latest technology. This motivation to learn refers to personal relevance that specifies the importance of learning to the learner's goals (Barak et al., 2016). Thus, it would be beneficial to consider a design pattern for a student review set in the future.

Transfer of Learning

Course design features are among the important factors for promoting transfer to real-world situations. The findings suggested that the participants used lots of checkpoints and their assignments were based on that. Further, they encouraged learners to complete projects that related to the real-world solutions, "… the entire course is basically a series of challenges where students are given real websites and asked them to debug." A comment from another participant, "So we promote a lot of those connections out to students to use in the real-world." Encourage learners to do such activities would benefit them, in terms of getting feedback from the instructors, peers, and they could also get to use it for their work. As pointed out in the literature, "learning-by-doing" may be most useful in preparing learners to apply the knowledge or skills gained in a learning environment to another context (DuFour, DuFour, Eaker, & Many, 2010).

What is perhaps more interesting is that one participant emphasized the value of learning activities and assignments when responding to a question about how they provide adequate practice for learners to apply new knowledge or skills for a variety of problems. “I don’t know if I’d quite call it adequate for mastering material as adequate for demonstrating that you have the capacity to master the material if that makes sense.” While training in professional environments have a clear goal (the job), this is not the case with most academic learning contexts. Learners are usually taught a broad set of knowledge and skills that they may apply in countless ways.

Limitations of the Study

The literature almost conclusively suggested that design patterns should be written collaboratively. Drafted patterns are typically shared, analyzed, evaluated, and refined through “shepherding” or a collaboration process within the pattern community. In other words, design patterns are a team effort and not created by a single person. Thus, the catalog of design patterns developed in this study should be analyzed and evaluated through a professional dialogue within the instructional design community. Also, there was some overlap between the pattern elements, and this suggested some revision of the design patterns with a group of practitioners are needed. External evaluation and feedback received during an extended process of collaboration can be used to refine design patterns, using varying perspectives from different practitioners. Brainstorming with researchers and practitioners involved in designing, developing, and delivering MOOCs is also necessary. In order to get useful information about learner needs and behavior, observing learner tendencies via log files analysis, evaluation reports, etc. are also significant.

The findings from expert interviews were based on the participants' own perceptions of their instructional design experience. Participants' perceptions are subjective and not necessarily verifiable by other sources of data. Furthermore, participants may not necessarily be able to provide the optimal method to design, develop, and deliver computer science MOOCs. However, understanding the experiences of these expert instructional designers may well lead to valuable insights into ways to enhance open online education, as well as more structured informal educational experiences for novice instructional designers.

The main challenge of cataloging design patterns was no agreed set of guidelines, procedures, and standards to define, organize, analyze, and evaluate patterns. Design patterns are not written down at once and forever, in which they are always work-in-progress (Kohls & Uttecht, 2009). Every feedback on the patterns brings in a new perspective and every successful application strengthens a pattern or introduces a new variation. On the other hand, each failure reflects constraints on the pattern and therefore, a clear understanding about its context as well as applicability can be realized.

The target group for this study was instructional designers. Some instructional designers might argue that design patterns limit their creativity by following the prescribed and proposed solutions. It might be true as design patterns describe design spaces instead of specific designs. Also, inappropriate use of design patterns could increase complexity, especially for novice designers who lack experience in designing open online courses. While design patterns developed in this study provided a detailed description of a problem and its solution in a generic form that can be understood by instructional designers, as well as professors, instructors, and teaching assistants, it must be noted that some of the problems and solutions were either too general or too specific.

Cataloging design patterns is important as it provides a common vocabulary for practitioners to communicate, document, and explore design alternatives. The first draft of the catalog was only a start, it was an effort to document the expertise of practitioners in open online learning. The catalog just documented the most common and existing design patterns that expert instructional designers used in designing open online courses. The underlying idea behind design patterns is to guide rather than instruct, a feature that makes them potentially a useful tool for designing effective learning courses. The catalog of design patterns did not provide a rigorous method, nor did it present a complete set of patterns that offers step-by-step instructions for designing an open online course. This study just documented the most common and related design patterns. Also, the design patterns were written at a higher level of abstraction, making a design seems less complex. Hence, creativity is absolutely needed in using the catalog of design patterns. Design scenarios represent the final stage of the design pattern development activity (Warburton & Mor, 2015). This study, however, only proposed one simple design scenario. Design scenarios usually use as design challenges to test design patterns. Future studies should include more authentic scenarios for open online learning activities.

Finally, I did not receive the degree of response to the interview request. Over 30 instructional designers were contacted for expert interviews, only two participated and completed the interviews. The number of interview participants was relatively small and more experts would probably improve the results of this study. Although these responses contributed important aspects to the findings, they were not adequate to address some of the open topics.

Recommendations for Future Research

The catalog of open online learning design patterns developed in this study should be further evaluated and refined through shepherding and pattern writing workshops. Design patterns are documented to allow other people learn from a good design (Kohls & Scheiter, 2008). Thus, it is important to evaluate if the catalog of design patterns could actually assist both novice and expert instructional designers in designing open online courses. The evaluation process should involve expert instructional designers and subject matter experts, allowing better evaluations of the resulting design patterns (Kohls & Scheiter, 2008).

In order to refine and perfect each design pattern, experts could provide guidance to the pattern author by giving specific suggestions on what could be done to improve it. The iterative and constructive feedback received during shepherding and pattern writing workshops not only could refine design patterns, but also could finalize design patterns for public release. Other than that, it is important to conduct experiments to investigate the effect of pattern application. This effort should be performed to demonstrate the use of design patterns by the application to the design of new open online courses.

Following evaluation and application, the catalog of open online learning design patterns should be published in an online repository for dissemination purposes. An online repository, for instance, in the form of Wiki could serve as a hub to foster collaboration between instructional designers and practitioners, allowing them to access, share, capture, modify, and apply design pattern knowledge and solutions to a specific instructional problem. Many people are familiar with the Wiki functionalities. Thus, instructional designers can easily share the results of pattern writing and evaluations of pattern applications, as well as provide recommendations and discuss issues related to design patterns.

Eventually, I hope to replicate this type of study in computer science cMOOCs. cMOOC is another form of massive open online learning based on collaboration and networking, fundamentally different from xMOOCs but more appropriate to address the needs of learners in a digital age. Since the focus of xMOOCs is more on the individual learner, the courses are didactic in nature in which the delivery of materials is via multimedia and videos, along with interactive and automated assessment to provide feedback on learning. On the other hand, cMOOCs emphasis on learning in a social context, enabling participants to create their own personal learning environment through the use of social media.

Conclusion

The use of design patterns has evolved to solve problems often encountered in architecture, prominently in software engineering and human computer interaction, and recently in the instructional design communities. Design patterns consist of reusable solutions generalized from a number of successful design cases and best practices. This study developed 15 design patterns that captured and presented solutions to problems in which the instructional designers could use when designing open online learning for computer science courses. The catalog of design patterns was based on the self-observation, thorough analysis of open online courses functionalities, literature review on pedagogical strategies, expert interviews, and existing published patterns in other related areas. Further research is needed to consider the analysis of learner log files in order to refine the design patterns.

Merrill's First Principles of Instruction served as a theoretical framework in this study. First principles prescribe a task-centered approach that integrates the solving of problems encountered in real-world situations with a direct instruction of problem components. The fifteen design patterns presented in this study can be used in conjunction with other few principles for teaching materials and learning activities, such as the collaboration, interaction, motivation, and navigation in designing a quality open online learning for computer science courses. Besides, this study also proposed a template to the instructional design community on how to effectively document and communicate design patterns in open education context. Designers can use this template to express their design expertise to other instructional design professionals and also make use of design patterns in practice.

APPENDIX A
RESEARCH PARTICIPATION REQUEST

Study Title: Cataloging Design Patterns for Open Online Learning in Computer Science Courses

Are you a current or former instructional designer? Have you created computer science modules for open online learning in the higher education environment?

If your answer to each of the above questions is yes, Nor Hafizah Adnan from University of Florida is conducting research to explore the experience and expertise of instructional designers in designing massive open online courses. The intention is to develop a catalog of design patterns for open online learning, a template for documenting and reusing successful design solutions.

Complete the initial Member Consent below to take part in the study. You will be sent a link to take a short (approximately 10 minutes) online survey to determine your eligibility for the study.

If you qualify, you will be contacted to schedule a web based interview to discuss your instructional design experiences. You will also be emailed the official consent form. The time required for participants in the online interview is approximately 60 minutes.

If you have additional questions, please contact Nor Hafizah Adnan at hafizah@ufl.edu

APPENDIX B
PRE SURVEY QUESTIONNAIRE

1. What is your gender?
2. What is your age range?
3. What is your highest degree earned?
4. What is your current title at the institution?
5. Do you have experience designing, developing, and delivering a Massive Open Online Course (MOOC) in the field of computer science? If “Yes,” please answer Questions 6, 7, 8, and 9.
6. At which MOOC platform or provider have you designed?
7. What course have you designed?
8. Who is the target audience for the MOOC?
9. On average, how many learners participate in the MOOC?
10. If you wish to help further and participate in a web-based interview, please provide the dates and times.
11. Please provide your email address.

APPENDIX C
INTERVIEW QUESTIONS

1. Do you use any existing content from the web in your MOOC? If so, what ways do you incorporate existing web content into your MOOC design?
2. What types of learner-to-learner and learner-to-content interactions (interactivity, communication, and collaboration) are available within your MOOC?

   Probe: How do you facilitate the learner-to-learner and learner-to-content interactions within your MOOC?
3. What media and technologies are being used in your MOOC and for what purpose (e.g., video -> content presentation)?

   Probes: How do you assist learners in becoming familiar and comfortable with the technologies used and/or operations of MOOC features? How do learners receive support when they might need assistance within the MOOC?
4. Did you evaluate the effectiveness of your MOOC before it went live? If so, describe the process?
5. How do learners measure or track personal learning progress?

   Probes: How do you help learners demonstrate their newly acquired skills? How do learners reflect within the course on what they have learned?
6. How do learners receive feedback on their learning (e.g., automated grading)?

   Probe: Do they receive frequent feedback on the strengths and weaknesses in their demonstrated learning?
7. How do you obtain learner feedback during the course? How do you obtain learner feedback after the course?

8. How do you assess the learning outcomes or results of those that participate in the MOOC?
9. In your experience, which approaches to instruction have proven to be the most effective in the implementation of the MOOC?

    Probes: Which factors affected your decision of adopting a particular approach for your instruction? Which factors affected your decision of not adopting a particular approach for your instruction? What types of approaches will you use in the future?

Now I'd like to go through your MOOC a step at a time and ask some questions.

10. What knowledge, skills, and dispositions are needed for the successful completion of the MOOC?
11. Please provide an outline of your designed course's lesson by lesson.

    Probes: What are the important steps in your instructional sequence? Do you provide different kinds of practice for different instructional goals?

12. Identify the lesson in your MOOC that performed the best.

    Probes: What do you think worked about this particular lesson in the MOOC? How do you ensure that the demonstration (if any) is consistent with the learning goal?

13. What motivates learners to participate in the MOOC?
14. What design features do you use to promote the activation of prior knowledge?
15. What design features do you use to promote transfer to real-world situations?

    Probe: How do you go about providing adequate practice for learners to use their new knowledge or skill for a variety of problems?

APPENDIX D
INTERVIEW TRANSCRIPT

Question (Q): Your participation in this study is completely voluntary and responses will remain anonymous. You have the right to withdraw from the study at any time if you feel uncomfortable. You do not have to answer any questions you do not want to answer. Thank you for agreeing to participate.

[Q1 Do you use any existing content from the web in your MOOC?]

Answer (A): Yes, I do.

Q: If so, what ways do you incorporate existing web content into your MOOC design?

A: I incorporate other sites from the web as examples or documentation.

[Q2 What types of learner-to-learner and learner-to-content interactions (interactivity, communication, and collaboration) are available within your MOOC? Probe: How do you facilitate the learner-to-learner and learner-to-content interactions within your MOOC?]

A: Well, the students have discussion forums and Slack for communication. Students can even connect to one another in-person through Udacity Connect.

[Q3 What media and technologies are being used in your MOOC and for what purpose (e.g., video -> content presentation)? Probes: How do you assist learners in becoming familiar and comfortable with the technologies used and/or operations of MOOC features? How do learners receive support when they might need assistance within the MOOC?]

A: We use video for quiz introductions, quiz solutions, tutorials, intros, outros, and explanations, and text for supporting information. While interactive programming quizzes for student self-assessment.

[Q4 Did you evaluate the effectiveness of your MOOC before it went live? If so, describe the process?]

A: No, we didn't.

[Q5 How do learners measure or track personal learning progress? Probes: How do you help learners demonstrate their newly acquired skills? How do learners reflect within the course on what they have learned?]

A: We display their progress on the site. Students demonstrate skills by building projects.

[Q6 How do learners receive feedback on their learning (e.g., automated grading)? Probe: Do they receive frequent feedback on the strengths and weaknesses in their demonstrated learning?]

A: Well, students receive automated feedback on most programming exercises and all other types of quizzes frequently. Students who are enrolled in the Nanodegree get personalized feedback from a grader on their project (cumulative assessment) at the end of the course.

[Q7 How do you obtain learner feedback during the course? How do you obtain learner feedback after the course?]

A: We watch the forums, talk to students and watch engagement numbers (number of learners progressing into the course).

[Q8 How do you assess the learning outcomes or results of those that participate in the MOOC?]

A: We measure the number of students who get jobs after completing the Nanodegree.

[Q9 In your experience, which approaches to instruction have proven to be the most effective in the implementation of the MOOC?]

A: Interactive and constant activities for students.

Q: Which factors affected your decision of adopting a particular approach for your instruction? Which factors affected your decision of not adopting a particular approach for your instruction? What types of approaches will you use in the future?

A: Engaging presentation of the content, less PowerPoint and more friend-sitting-next-to-you-explaining-things. I used to teach science. Hands on is the best, so I made my classes as hands on as possible.

Q: Now I'd like to go through your MOOC a step at a time and ask some questions.

[Q10 What knowledge, skills, and dispositions are needed for the successful completion of the MOOC?]

A: Basic web development skills, good attitude, and willingness to try things.

[Q11 Please provide an outline of your designed course's lesson by lesson. Probes: What are the important steps in your instructional sequence? Do you provide different kinds of practice for different instructional goals?]

A: Cannot - NDA.

[Q12 Identify the lesson in your MOOC that performed the best. Probes: What do you think worked about this particular lesson in the MOOC? How do you ensure that the demonstration (if any) is consistent with the learning goal?]

A: Unknown, I haven't measured.

[Q13 What motivates learners to participate in the MOOC?]

A: Improve web development skills and build websites faster.

[Q14 What design features do you use to promote the activation of prior knowledge?]

A: Practice. Students constantly work with sites.

[Q15 What design features do you use to promote transfer to real-world situations? Probe: How do you go about providing adequate practice for learners to use their new knowledge or skill for a variety of problems?]

A: The entire course is basically a series of challenges where students are given real-websites and are asked to debug them.

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BIOGRAPHICAL SKETCH

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