

The Students' Guide to Learning Design and Research

Royce Kimmons & Secil Caskurlu

Table of Contents

About this Book	1
Learning Theories	3
Behaviorism	5
Cognitivism	11
Constructivism	17
Socioculturalism	23
Research Methods	31
Case Studies	33
Design-Based Research	37
Inferential Statistics	43
Learning Analytics	49
Psychometrics	55
Design and Development	63
Continuous Improvement Dashboards	65
Copyright	73
Design Layers	79
Gamification	85
Informal Learning	93
Instructional Design Methods	101
Personalized and Blended Learning	105
Project-Based Learning	117
Reflection	123
Role-Play	133
Secure Web Application Development	139
Socratic Seminar	145
Visual Aesthetics	155
List of Authors	165



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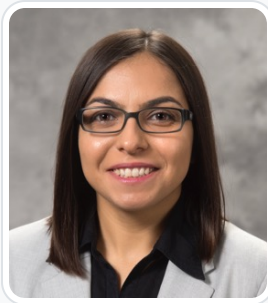
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Royce Kimmons

Brigham Young University

Royce Kimmons is an Associate Professor of Instructional Psychology and Technology at Brigham Young University where he seeks to end the effects of socioeconomic divides on educational opportunities through open education and transformative technology use. He is the founder of EdTechBooks.org, open.byu.edu, and many other sites focused on providing free, high-quality learning resources to all. More information about his work may be found at <http://roycekimmons.com>, and you may also dialogue with him on Twitter [@roycekimmons](https://twitter.com/roycekimmons).



Secil Caskurlu

Michigan State University

Dr. Secil Caskurlu is a Research Associate in the Educational Psychology and Educational Technology program at Michigan State University. Her research focuses on the factors that impact learner outcomes and how to integrate them into the design, development and evaluation phases as they relate to learning environments, experiences, technologies and the like. Please visit <https://secilcaskurlu.wordpress.com> to find more information about her work.



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About this Book

Royce Kimmons

This book is a continually-evolving class project for students across multiple semesters.

It is called "the students' guide," because it has been written by students for students.

Each semester that I teach a writing or research course, I give my students the option to write chapters for this book on topics that interest them. Some are first-year graduate students; others are close to defending theses and dissertations. Though not yet experts in the field, these students know what it is like to be a student and also know how to make difficult concepts manageable for their peers. Thus, the true value of their contributions to this book lies in their ability to speak to their peers through its chapters in a way that is clear and meaningful at their stage of academic development.

Contributing to this Book

All students at any university are welcome to contribute to this book by submitting new chapters or revisions of current chapters with substantial updates. Since all chapters are released under a Creative Commons license, any updated chapters will include the name of the new author as a co-author.

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Learning Theories

Behaviorism
Cognitivism
Constructivism
Socioculturalism

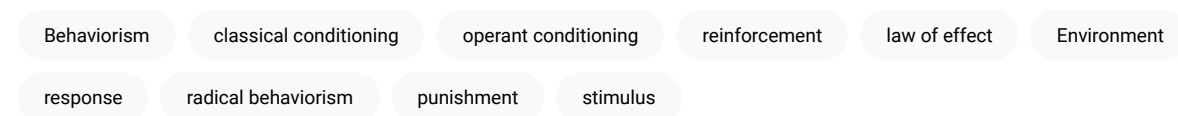


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Behaviorism

Bekki Brau, Nathan Fox, & Elizabeth Robinson



Behaviorism is an area of psychological study that focuses on observing and analyzing how controlled environmental changes affect behavior. The goal of behavioristic teaching methods is to manipulate the environment of a subject — a human or an animal — in an effort to change the subject’s observable behavior. From a behaviorist perspective, learning is defined entirely by this change in the subject’s observable behavior. The role of the subject in the learning process is to be acted upon by the environment; the subject forms associations between stimuli and changes behavior based on those associations. The role of the teacher is to manipulate the environment in an effort to encourage the desired behavioral changes. The principles of behaviorism were not formed overnight but evolved over time from the work of multiple psychologists. As psychologists’ understanding of learning has evolved over time, some principles of behaviorism have been discarded or replaced, while others continue to be accepted and practiced.

History of Behaviorism

A basic understanding of behaviorism can be gained by examining the history of four of the most influential psychologists who contributed to the behaviorism: Ivan Pavlov, Edward Thorndike, John B. Watson, and B.F. Skinner. These four did not each develop principles of behaviorism in isolation, but rather built upon each other’s work.

Ivan Pavlov

Ivan Pavlov is perhaps most well-known for his work in conditioning dogs to salivate at the sound of a tone after pairing food with the sound over time. Pavlov’s research is regarded as the first to explore the theory of classical conditioning: that stimuli cause responses and that the brain can associate stimuli together to learn new responses. His research also studied how certain parameters — such as the time between two stimuli being presented — affected these associations in the brain. His exploration of the stimulus-response model, the associations formed in the brain, and the effects of certain parameters on developing new behaviors became a foundation of future experiments in the study of human and animal behavior (Hauser, 1997).

In his most famous experiment, Pavlov started out studying how much saliva different breeds of dogs produced for digestion. However, he soon noticed that the dogs would start salivating even before the food was provided. Subsequently he realized that the dogs associated the sound of him walking down the stairs with the arrival of food. He went on to test this theory by playing a tone when feeding the dogs, and over time the dogs learned to salivate at the sound of a tone even if there was no food present. The dogs learned a new response to a familiar stimulus via stimulus association. Pavlov called this learned response a conditional reflex. Pavlov performed several variations of this experiment, looking at how far apart he could play the tone before the dogs no longer associated the sound with food;

or if applying randomization — playing the tone sometimes when feeding the dogs but not others — had any effect on the end results (Pavlov, 1927).

Pavlov's work with conditional reflexes was extremely influential in the field of behaviorism. His experiments demonstrate three major tenets of the field of behaviorism:

1. Behavior is learned from the environment. The dogs learned to salivate at the sound of a tone after their environment presented the tone along with food multiple times.
2. Behavior must be observable. Pavlov concluded that learning was taking place because he observed the dogs salivating in response to the sound of a tone.
3. All behaviors are a product of the formula stimulus-response. The sound of a tone caused no response until it was associated with the presentation of food, to which the dogs naturally responded with increased saliva production.

These principles formed a foundation of behaviorism on which future scientists would build.

Edward Thorndike

Edward Lee Thorndike is regarded as the first to study operant conditioning, or learning from consequences of behaviors. He demonstrated this principle by studying how long it took different animals to push a lever in order to receive food as a reward for solving a puzzle. He also pioneered the law of effect, which presents a theory about how behavior is learned and reinforced.

One experiment Thorndike conducted was called the puzzle box experiment, which is similar to the classic “rat in the maze” experiment. For this experiment, Thorndike placed a cat in a box with a piece of food on the outside of the box and timed how long it took the cat to push the lever to open the box and to get the food. The first two or three times each cat was placed in the box there was little difference in how long it took to open the box, but subsequent experiments showed a marked decrease in time as each cat learned that the same lever would consistently open the box.

A second major contribution Thorndike made to the field is his work in pioneering the law of effect. This law states that behavior followed by positive results is likely to be repeated and that any behavior with negative results will slowly cease over time. Thorndike's puzzle box experiments supported this belief: animals were conditioned to frequently perform tasks that led to rewards.

Thorndike's two major theories are the basis for much of the field of behaviorism and psychology studies of animals to this day. His results that animals can learn to press levers and buttons to receive food underpin many different types of animal studies exploring other behaviors and created the modern framework for the assumed similarities between animal responses and human responses (Engelhart, 1970).

In addition to his work with animals, Thorndike founded the field of educational psychology and wrote one of the first books on the subject, *Educational Psychology*, in 1903. Much of his later career was spent overhauling the field of teaching by applying his ideas about the law of effect and challenging former theories on generalized learning and punishment in the classroom. His theories and work have been taught in teaching colleges across the world.

John B. Watson

John Broadus Watson was a pioneering psychologist who is generally considered to be the first to combine the multiple facets of the field under the umbrella of behaviorism. The foundation of Watson's behaviorism is that consciousness — introspective thoughts and feelings — can neither be observed nor controlled via scientific methods and therefore should be ignored when analyzing behavior. He asserted that psychology should be purely objective, focusing solely on predicting and controlling observable behavior, thus removing any interpretation of conscious experience. Thus, according to Watson, learning is a change in observable behavior. In his 1913 article “Psychology as the Behaviorist Views It”, Watson defined behaviorism as “a purely objective experimental branch of natural science” that “recognizes

no dividing line between man and brute.” The sole focus of Watson’s behaviorism is observing and predicting how subjects outwardly respond to external stimuli.

John Watson is remembered as the first psychologist to use human test subjects in experiments on classical conditioning. He is famous for the Little Albert experiment, in which he applied Pavlov’s ideas of classical conditioning to teach an infant to be afraid of a rat. Prior to the experiment, the nine-month-old infant Albert was exposed to several unfamiliar stimuli: a white rat, a rabbit, a dog, a monkey, masks with and without hair, cotton wool, burning newspapers, etc. He showed no fear in response. Through some further experimentation, researchers discovered that Albert responded with fear when they struck a steel bar with a hammer to produce a sharp noise.

During the experiment, Albert was presented with the white rat that had previously produced no fear response. Whenever Albert touched the rat, the steel bar was struck, and Albert fell forward and began to whimper. Albert learned to become hesitant around the rat and was afraid to touch it. Eventually, the sight of the rat caused Albert to whimper and crawl away. Watson concluded that Albert had learned to be afraid of the rat (Watson & Rayner, 1920).

By today’s standards, the Little Albert experiment is considered both unethical and scientifically inconclusive. Critics have said that the experiment “reveals little evidence either that Albert developed a rat phobia or even that animals consistently evoked his fear (or anxiety) during Watson’s experiment” (Harris, 1997). However, the experiment provides insight into Watson’s definition of behaviorism — he taught Albert by controlling Albert’s environment, and the change in Albert’s behavior led researchers to conclude that learning had occurred.

B. F. Skinner

Skinner was a psychologist who continued to influence the development of behaviorism. His most important contributions were introducing the idea of radical behaviorism and defining operant conditioning.

Unlike Watson, Skinner believed that internal processes such as thoughts and emotions should be considered when analyzing behavior. The inclusion of thoughts and actions with behaviors is radical behaviorism. He believed that internal processes, like observable behavior, can be controlled by environmental variables and thus can be analyzed scientifically. The application of the principles of radical behaviorism is known as applied behavior analysis.

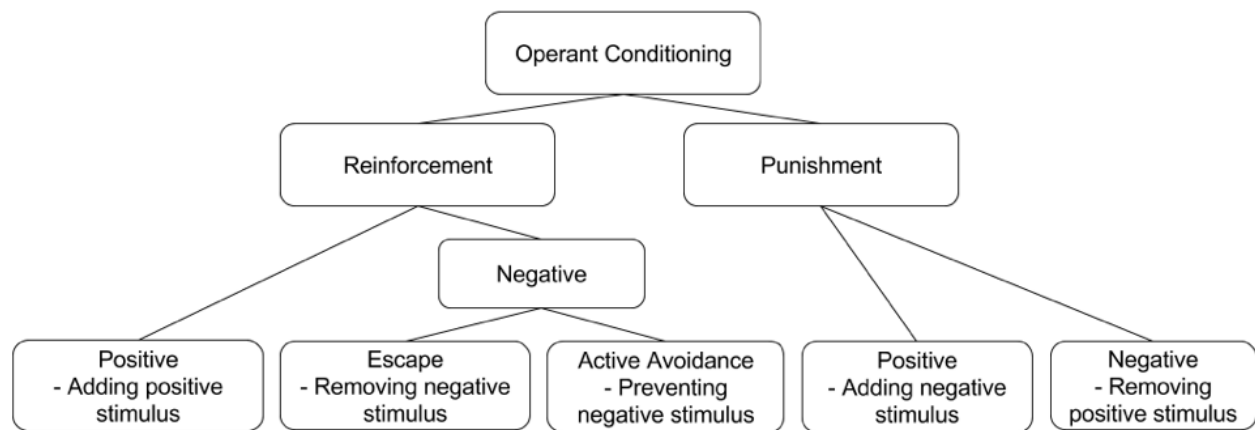
In 1938, Skinner published *The Behavior of Organisms*, a book that introduces the principles of operant conditioning and their application to human and animal behavior. The core concept of operant conditioning is the relationship between reinforcement and punishment, similar to Thorndike’s law of effect: Rewarded behaviors are more likely to be repeated, while punished behaviors are less likely to be repeated. Skinner expounded on Thorndike’s law of effect by breaking down reinforcement and punishment into five discrete categories (cf. Fig. 1):

- Positive reinforcement is adding a positive stimulus to encourage behavior.
- Escape is removing a negative stimulus to encourage behavior.
- Active avoidance is preventing a negative stimulus to encourage behavior.
- Positive punishment is adding a negative stimulus to discourage behavior.
- Negative punishment is removing a positive stimulus to discourage behavior.

Reinforcement encourages behavior, while punishment discourages behavior. Those who use operant conditioning use reinforcement and punishment in an effort to modify the subject’s behavior.

Figure 1

An Overview of the Five Categories of Operant Conditioning



Positive and negative reinforcements can be given according to different types of schedules. Skinner developed five schedules of reinforcement:

- Continuous reinforcement is applied when the learner receives reinforcement after every specific action performed. For example, a teacher may reward a student with a sticker for each meaningful comment the student makes.
- Fixed interval reinforcement is applied when the learner receives reinforcement after a fixed amount of time has passed. For example, a teacher may give out stickers each Friday to students who made comments throughout the week.
- Variable interval reinforcement is applied when the learner receives reinforcement after a random amount of time has passed. For example, a teacher may give out stickers on a random day each week to students who have actively participated in classroom discussion.
- Fixed ratio reinforcement is applied when the learner receives reinforcement after the behavior occurs a set number of times. For example, a teacher may reward a student with a sticker after the student contributes five meaningful comments.
- Variable ratio reinforcement is applied when the learner receives reinforcement after the behavior occurs a random number of times. For example, a teacher may reward a student with a sticker after the student contributes three to ten meaningful comments.

Skinner experimented using different reinforcement schedules in order to analyze which schedules were most effective in various situations. In general, he found that ratio schedules are more resistant to extinction than interval schedules, and variable schedules are more resistant than fixed schedules, making the variable ratio reinforcement schedule the most effective.

Skinner was a strong supporter of education and influenced various principles on the manners of educating. He believed there were two reasons for education: to teach both verbal and nonverbal behavior and to interest students in continually acquiring more knowledge. Based on his concept of reinforcement, Skinner taught that students learn best when taught by positive reinforcement and that students should be engaged in the process, not simply passive listeners. He hypothesized that students who are taught via punishment learn only how to avoid punishment. Although Skinner's doubtful view on punishment is important to the discipline in education, finding other ways to discipline are very difficult, so punishment is still a big part in the education system.

Skinner points out that teachers need to be better educated in teaching and learning strategies (Skinner, 1968). He addresses the main reasons why learning is not successful. This biggest reasons teachers fail to educate their students are because they are only teaching through showing and they are not reinforcing their students enough. Skinner gave examples of steps teachers should take to teach properly. A few of these steps include the following:

1. Ensure the learner clearly understands the action or performance.
2. Separate the task into small steps starting at simple and working up to complex.
3. Let the learner perform each step, reinforcing correct actions.
4. Regulate so that the learner is always successful until finally the goal is reached.
5. Change to random reinforcement to maintain the learner's performance (Skinner, 1968).

Criticisms and Limitations

While there are elements of behaviorism that are still accepted and practiced, there are criticisms and limitations of behaviorism. Principles of behaviorism can help us to understand how humans are affected by associated stimuli, rewards, and punishments, but behaviorism may oversimplify the complexity of human learning. Behaviorism assumes humans are like animals, ignores the internal cognitive processes that underlie behavior, and focuses solely on changes in observable behavior.

From a behaviorist perspective, the role of the learner is to be acted upon by the teacher-controlled environment. The teacher's role is to manipulate the environment to shape behavior. Thus, the student is not an agent in the learning process, but rather an animal that instinctively reacts to the environment. The teacher provides input (stimuli) and expects predictable output (the desired change in behavior). More recent learning theories, such as constructivism, focus much more on the role of the student in actively constructing knowledge.

Behaviorism also ignores internal cognitive processes, such as thoughts and feelings. Skinner's radical behaviorism takes some of these processes into account insofar as they can be measured but does not really try to understand or explain the depth of human emotion. Without the desire to understand the reason behind the behavior, the behavior is not understood in a deeper context and reduces learning to the stimulus-response model. The behavior is observed, but the underlying cognitive processes that cause the behavior are not understood. The thoughts, emotions, conscious state, social interactions, prior knowledge, past experiences, and moral code of the student are not taken into account. In reality, these elements are all variables that need to be accounted for if human behavior is to be predicted and understood accurately. Newer learning theories, such as cognitivism, focus more on the roles of emotion, social interaction, prior knowledge, and personal experience in the learning process.

Another limitation to behaviorism is that learning is only defined as a change in observable behavior. Behaviorism operates on the premise that knowledge is only valuable if it results in modified behavior. Many believe that the purpose of learning and education is much more than teaching everyone to conform to a specific set of behaviors. For instance, Foshay (1991) argues that "the one continuing purpose of education, since ancient times, has been to bring people to as full as realization as possible of what it is to be a human being" (p. 277). Behaviorism's focus on behavior alone may not achieve the purpose of education, because humans are more than just their behavior.

Conclusion

Behaviorism is a study of how controlled changes to a subject's environment affect the subject's observable behavior. Teachers control the environment and use a system of rewards and punishments in an effort to encourage the desired behaviors in the subject. Learners are acted upon by their environment, forming associations between stimuli and changing behavior based on those associations.

There are principles of behaviorism that are still accepted and practiced today, such as the use of rewards and punishments to shape behavior. However, behaviorism may oversimplify the complexity of human learning; downplay the role of the student in the learning process; disregard emotion, thoughts, and inner processes; and view humans as being as simple as animals.

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Cognitivism

Esther Michela

Cognitivism

information processing theory

long-term memory

Self-regulated Learning

Cognitive Load Theory

Attention

short-term memory

working memory

Cognitive learning theories cover a wide range of ideas from the work of many researchers. It is a continually developing field which has influenced and been influenced by the developments in different fields including instructional design, developmental psychology, cognitive psychology, and increasingly cognitive neuropsychology. Cognitive learning theories focus on the ability of students to guide their own learning using mental strategies. The purpose of this chapter is to (a) briefly explore the growth of cognitivism, (b) explain some of the relevant cognitive processes identified within cognitivism, (c) provide an overview of several cognitive learning theories, and (d) describe the relevance of cognitivism to instructional design practices. These areas will provide an instructional design student with knowledge of theories that can be applied in situations for learners with varied learning needs.

Growth of Cognitivism

Cognitivist learning theories are understood to have stemmed from the inadequacies of the behaviorist learning theories of strict stimulus and response training to fully explain how learning occurs. Petri and Mishkin (1994) point to the work of researchers Edward Tolman, Wolfgang Kohler, and Ivan Krechevsky on the role of expectations, insight, purpose, and hypothesis making in the early 1920s and 30s as the earliest forays into cognitivist research. However, it was not until the 1950s that cognitive theories began to gain discernible traction and attention.

The definition and scope of cognitivism has evolved over the years. Early studies of cognition explored the active acquisition of knowledge as opposed to the more passive learner approach of behaviorism (Woolfolk, 2015). According to more recent views such as those of Ertmer and Newby (1994), “cognitive theories focus on the conceptualization of a student’s learning processes and address issues of how information is received, organized, stored, and retrieved by the mind” (p. 58). An early model of cognitivism, known as the two-store or dual memory model, refers to the interactions between working memory and long-term memory. The two-store (dual) model is now seen as simplistic and incomplete but serves as a starting point for understanding cognitive learning theories. As the field of cognitivism has expanded, more theories have been developed so that there is no universal cognitive model or theory of learning accepted by all cognitive scientists.

Cognitive Processes

In this section I will briefly explain the cognitive processes related to the two-store (dual) memory model including (a) perception, (b) executive processes, (c) working memory, (d) encoding, and (e) long-term memory. These do not include all of the cognitive processes involved in learning, but these are the ones most commonly addressed in the cognitivist

view of learning. I acknowledge that each process is complex and have entire books written about them. However, I will attempt to provide a working definition and description based on current knowledge that is most relevant to cognitivist learning theories.

Perception

The process of receiving information begins with some sort of sensory input: the sound of a bell, the smell of a rose, the touch of a feather, the taste of honey, or the sight of a friend. Each of the five sensory systems in our bodies has its own complex pathway for registering and assigning meaning to, or perceiving, that input. It is generally based on context and patterns of what is already known. The body receives large amounts of sensory data constantly since we touch, see, hear, taste, and smell all the time, even though we are not conscious to all of it at once. Sensory information stays only a very short time in the sensory register, though time estimates vary between less than a second to up to three seconds. Then the information is transferred to short-term or working memory (Schunk, 2012 p. 165; Woolfolk, 2015, p. 294).

Executive processes

Executive, or control, processes “regulate the flow of information throughout the information processing system” (Schunk, 2012, p. 166). These include the conscious processes and effort a person exerts in managing new information as it is presented including directing attention, planning next steps, and retrieving information from long-term memory for current use (Woolfolk, 2015, p. 298). It is often linked to working memory but has influence in all parts of the two-store model. Executive processes are also used to monitor understanding, select learning strategies, and regulate motivation. I will focus mainly on attention here, as it fits chronologically in the two-store model, but will keep in mind that cognitivists believe that learners play a conscious, active role in the learning process, so the executive control functions affect each stage of the process.

Attention is selective, which allows us, with effort, to ignore or acknowledge pertinent sensory input. We would be overwhelmed if we tried to pay attention to every bit of competing sensory information at once. For example, in a classroom, one could see the notes on the board, the teacher’s new hairstyle, and the current heart-throb sitting 2 seats over, all while feeling an itchy shirt tag, and smelling the students returning from gym. Cutting through all of the sensory input, one needs to decide where to focus attention. There are individual differences in one’s ability to initiate and maintain attention, based on age, motivation, self-control, learning disabilities, and familiarity with the subject matter. The more familiar someone is with a skill or context, the less conscious attention they need to exert in processing and the more capacity they have to take in new information (Schunk, 2012).

Short-term or working memory

While short-term and working memory are not considered synonymous by all researchers, they are often used interchangeably. Schunk (2012) says that short-term memory is “a working memory and corresponds roughly to awareness, or what one is conscious of at a given moment” (p.179). Woolfolk (2015) distinguishes the two in that working memory “includes both temporary storage and active processing,” while short-term memory is usually referred to only as temporary storage of information (p. 297). It is generally agreed upon that short-term and working memory are limited in both capacity and duration, and information will be lost if it is not constantly rehearsed or transferred to long-term memory. Chunking, or segmenting, information into smaller pieces or groups may help reduce the load on working memory. For example, instead of one long string of numbers, telephone numbers are segmented into three sections.

Based on current understanding, there are four elements in working memory that process different types of sensory input: the central executive, which controls attention and mental resources; the phonological loop, which processes verbal and auditory information; the visuospatial sketchpad, which works on visual and spatial information; and the episodic buffer, which integrates information from the previous processors with information from long-term memory to make sense of it all (Woolfolk, 2015, p. 298). The processors can be used strategically, for instance to memorize a phone number given verbally. I would exert my executive control by constantly repeating the number out loud, using the phonological loop to rehearse until I could write it down, creating a visual image. I could then continue to rehearse the

number out loud while visualizing the number in my head, drawing on the visuospatial sketchpad. I could use my prior knowledge of ZIP codes or number patterns to make connections with more familiar numbers until the number was memorized. These four elements of working memory are important for an instructional designer to understand as they consider strategies to assist learners. This leads us to a further discussion of encoding.

Encoding

Encoding is the process of integrating new information processed in the working memory with what is already known to facilitate storage in the long-term memory. Encoding is influenced by organization, elaboration, and schema (Schunk, 2012, p. 187). For cognitivist researchers, encoding is where the magic happens. This is where all of the cognitive processes and executive control functions work together to “learn” new information and store it for future use.

Gestalt theory developed in the early 1900s refers to our “tendency to organize sensory information into patterns or relationships” (Woolfolk, 2015, p. 294). While the Gestalt theory is now essentially disproved, it provided early insight into human perception, showed that organized material is easier to recall, and revealed that humans will often impose order and meaning when there is none apparent (Schunk, 2012). Organizational strategies include creating hierarchies, mnemonic techniques, and mental imagery. Organization of material enhances memory, because it connects new information to what is already known, and when one piece of information is activated, or cued, it will activate connected information as well.

“Elaboration is the process of expanding upon new information by adding to it or linking it to what one knows” (Schunk, 2012, p. 188). Mnemonic devices can assist with elaboration by giving meaning to something easily remembered, such as using the first letter of the order of operations in math: Please Excuse My Dear Aunt Sally (Parentheses, Exponents, Multiplication, Division, Addition, Subtraction). I used elaboration in memorizing the license plate number on my old car, 6AT1830. There are six children in my family, so I linked that information to the six. AT formed the word “at,” and 1830 could be the military time for 6:30. I asked myself the question, “How many for dinner?” The answer is 6 at 6:30 (or 1830). It may seem a convoluted process to memorize, but it has stuck, so much so that after I bought a new car and switched license plates, I still try to give the old plate number. The process of elaborating new information with meaningful knowledge increases the likelihood that it will be remembered.

Schemas or schemata are personalized organizational structures. They encompass our general knowledge of specific situations that are used to plan our actions and interactions. They often prescribe a routine of actions based on our past experience (Schunk, 2012, p. 189). For example, a schema could be the process of ordering fast food. For one person, the schema may include using the drive through, carefully considering different options on the menu, ordering their meal, pulling forward, paying, and then eating on the road. The schema for another customer might include going inside the restaurant, ordering the same items as always, chatting with the employees, and sitting down to eat. Any schema about ordering fast food allows a person to go into the situation with some prior knowledge and expectations of the process.

Schemas can also assist in processing new information using a pre-existing or familiar structure. For example, a schema for a Hollywood romantic comedy would contain consistent elements. When watching the newly released summer blockbuster, a moviegoer would likely recognize familiar types of characters, themes, and plot points: the heroine, the love interest, the misunderstanding or obstacle to the relationship, and the eventual happy ending. Schemas can help learners encode by integrating new information with familiar knowledge and structure.

Long-term memory

Petri and Mishkin (1994) define memory as “the ability to store sensory information for later retrieval as images, thoughts and idea” (p. 33). What is referred to as memory in common speech generally means long-term memory where images, thoughts, and ideas are stored for greater lengths of time. While short-term memory is limited in duration and capacity, long-term memory is, theoretically, unlimited in both. Information is generally stored in long-term memory as verbal representations, though as ideas rather than in specific sentences. For example, when trying to recall something my friend said yesterday, I am likely to remember the idea and recreate it in my own words instead of repeating my

friend's words verbatim. Information can also be stored as visual images. Stored information is accessed through cues, such as a question or request for information.

It is important for instructional designers to know that information is more easily accessed in long-term memory when it has been associated with meaningful connections, organized, and elaborated sufficiently (Schunk, 2012, p. 194). Frequent retrieval of information through review strengthens a learner's ability to access that information in the future. The more automatically the information can be accessed, the more easily it can be retrieved and the more useful it can be in learning future related concepts.

Cognitive Theories of Learning

There are multiple theories of both learning and the cognitive processes themselves. The theories of learning presented here are some of the most well known and applicable in the field of instructional design.

Information Processing Theories

Information processing theories are varied but generally deal with how people attend to environmental events, encode information to be learned and relate it to knowledge in memory, store new knowledge in memory, and retrieve it as needed (Shuell, 1986). The computer information processing system of receiving information (input), storing information (encoding), and retrieving that information as directed (output) was an early analogy for how a human mind processes information, as was discussed earlier as the two-store model. This analogy has gained complexity over time, but information processing theorists generally assume that information processing in human minds occurs in stages between receiving a stimulus (input) and producing a response (output), though theorists differ in how closely they adhere to the computer model. The form or mental representation of the information differs depending on the stage of processing. Another assumption is "that information processing is involved in all cognitive activities: perceiving, rehearsing, thinking, problem solving, remembering, forgetting, and imaging" (Schunk, 2012, p.165). Information processing theory can be useful to instructional designers in learning situations requiring the recall of specific information. Instructional designers could focus on encouraging strategies to maximize encoding and retrieval.

Cognitive Load Theory

Cognitive load theory proposes that a finite amount of information can be processed in the mind at one time, based on the limits of perception, attention, and working memory (Schunk, 2012, pp. 223-224). Drinking from a firehose is an apt analogy in that the demands of an activity can exceed the capacity of a person to absorb what is being given. Sweller (2011) suggests that long-term memory is of primary importance to the nature of learning because "we use it to determine the bulk of our activity." Experts are those who have stored large amounts of information about a certain topic in long-term memory and can draw upon it to solve problems. The problem, therefore, is to efficiently transfer information through the biological constraints of our short-term or working memory into long-term memory.

All new information exerts some load on our working memory. Cognitive load theorists recognize two main types of load: intrinsic and extrinsic. An intrinsic cognitive load is related to the complexity of the information itself compared to the expertise of the learner and can only be changed when the learners have the necessary cognitive processing strategies (Sweller, 2011). Extrinsic load refers to the way in which "material is presented or the activities required of the learner" (Schunk, 2012, p. 224).

Scaffolding and the use of schema can help reduce cognitive load in instruction as it allows learners to reduce the demands on their cognitive resources, especially working memory. This can be accomplished by providing clear instruction, reducing redundant information, presenting information both visually and aurally, allowing students to learn elements separately (e.g. individual chemical symbols), demonstrating problem solving, and removing more elementary information from explanations to students with higher levels of expertise (Sweller, 2011).

Self-Regulated Learning

Self-regulation as defined by Zimmerman (2001) “refers to the self-directive process through which learners transform their mental abilities into task-related academic skills” (p. 1). Like other cognitivist theories, this assumes that students are actively involved in the learning process, showing initiative, perseverance, and adaptive skills in pursuing the learning, be it on their own or through social interaction (Zimmerman, 2001). Research into self-regulated learning (SRL) began in the mid-1980s and has grown to encompass its own set of varying theoretical perspectives including operant, phenomenological, information processing, social cognitive, volitional, Vygotskian, and cognitive constructivist approaches, which can be studied in detail in Zimmerman and Schunk (2001), and which share a few common features.

SRL theories assume that (a) students can personally improve their ability to learn through selective use of metacognitive and motivational strategies; (b) can proactively select, structure, and even create advantageous learning environments; and (c) can play a significant role in choosing the form and amount of instruction they need. (Zimmerman, 2001, p.5)

Of primary importance is the opportunity for a learner to choose what they want to learn, why they want to learn it, with whom and where the learning will take place, and how much they need to learn (Zimmerman, B. & Schunk, D., 2001, p. 301). Instructional designers can take the principles of self-regulated learning into consideration by providing opportunities for learners to control some aspects of their learning environment.

Relevance to Instructional Design

Much of the research done in cognitive science has been done in laboratory settings without direct application to educational settings. There is a need for instructional design to bridge the gap between learning research and educational practices according to Ertmer and Newby (1993, p. 50). Different theories may be appropriate for use in different learning environments and for different learners. For example, behaviorist principles of stimulus and response can be useful during the learning of facts, such as the multiplication tables. However, cognitive theories are generally useful for more complex learning tasks.

According to cognitivist learning theories, a primary goal is to transfer knowledge to the learner in the most efficient way by allowing the learner to use the most effective cognitive strategies to encode information. Therefore, an instructional designer must consider both the learning task requirements and the current capabilities of the learner. By conducting a cognitive task analysis, the designer can determine the learner's current level of learning skills and the most efficient presentation of information. Since cognitivist theories support the active involvement of the learner, goal setting, planning, and self-monitoring are strategies that should be encouraged. When processing new information, it can be helpful for designers to provide opportunities for learners to organize the material in ways that connect to prior knowledge or personal experiences (Ertmer & Newby, 1986, pp. 60-61).

A general principle of instructional design associated with cognitivism is that information will be more efficiently processed if it is provided in manageable pieces. Therefore, presenting information in a way that reduces the load on working memory will facilitate encoding in long-term memory. Use of feedback is also important. Unlike with behaviorism where the purpose of feedback is to strengthen cue and response, in cognitivism feedback is used to provide the learner with information about the effectiveness of their strategies. Therefore, instructional designers should plan ways for learners to receive prompt feedback on their efforts so that the learners may more effectively plan ahead for future learning situations.

Conclusion

The cognitivist approach to learning assumes that the learner uses cognitive processes as an active participant in the learning process. The variety in the learning objectives and student capacities in any given situation require an instructional designer to have a breadth and depth of knowledge of instructional theories in order to meet the needs of

each situation. There is no one theory to rule them all. (Apologies to J.R.R. Tolkien.) However, the principles of cognitivism provide useful paradigms for instructional designers as they create effective learning environments to meet the needs of a wide range of learners.

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Constructivism

Bekki Brau

Zone of Proximal Development

Social Constructivism

Accommodation

Radical (Cognitive) Constructivism

Assimilation

Constructivism is a learning theory which holds that knowledge is best gained through a process of reflection and active construction in the mind (Mascolo & Fischer, 2005). Thus, knowledge is an intersubjective interpretation. The learner must consider the information being taught and - based on past experiences, personal views, and cultural background - construct an interpretation. Constructivism is split into two main camps: radical and social. The first form radical (or cognitive) constructivism proposes that the process of constructing knowledge is dependent on the individual's subjective interpretation of their active experience. The second form social constructivism affirms that human development is socially situated and that knowledge is constructed through interaction with others. This chapter discusses the history, practice, examples in education and limitations.

History

There are three foundational psychologists of constructivism. Jean Piaget falls into the radical constructivism camp. Lev Vygotsky, on the other hand, concentrates on the social aspects of learning through experiences. John Dewey straddles the line between the two perspectives and has many ideas that match with each side. The common ground that united these psychologists under the umbrella of constructivism is that all three believed that the learning theories (e.g behaviorism and humanism) at the time did not adequately represent the actual learning process. In addition, their ideas were rooted in experiences in the classroom instead of experiments in a lab (compared to behaviorism).

Jean Piaget

Jean Piaget is known as one of the first theorists in constructivism. His theories indicate that humans create knowledge through the interaction between their experiences and ideas. His view of constructivism is the inspiration for radical constructivism due to his idea that the individual is at the center of the knowledge creation and acquisition process. The vast majority of Piaget's theories develop through working with children where he would challenge the idea that children are inferior thinkers compared to adults. His work provides evidence that children are not cognitively inferior to adults. He proves that children develop differently by establishing a theory involving cognitive stages.

Piaget's cognitive theory explores how children develop. His theory splits development into four discrete stages. Although Piaget never linked his research on cognitive development to education directly, his theory plays a pivotal role in his contributions to learning theories.

Based on the research into children's cognitive development Piaget identified processes of accommodation (reframing one's mental representation of the external world to fit new experiences) and assimilation (the process by which a

person or persons acquire the social and psychological characteristics of a group) which are key in the interaction between experiences and ideas. These two processes focus on how learning occurs rather than what influences learning.

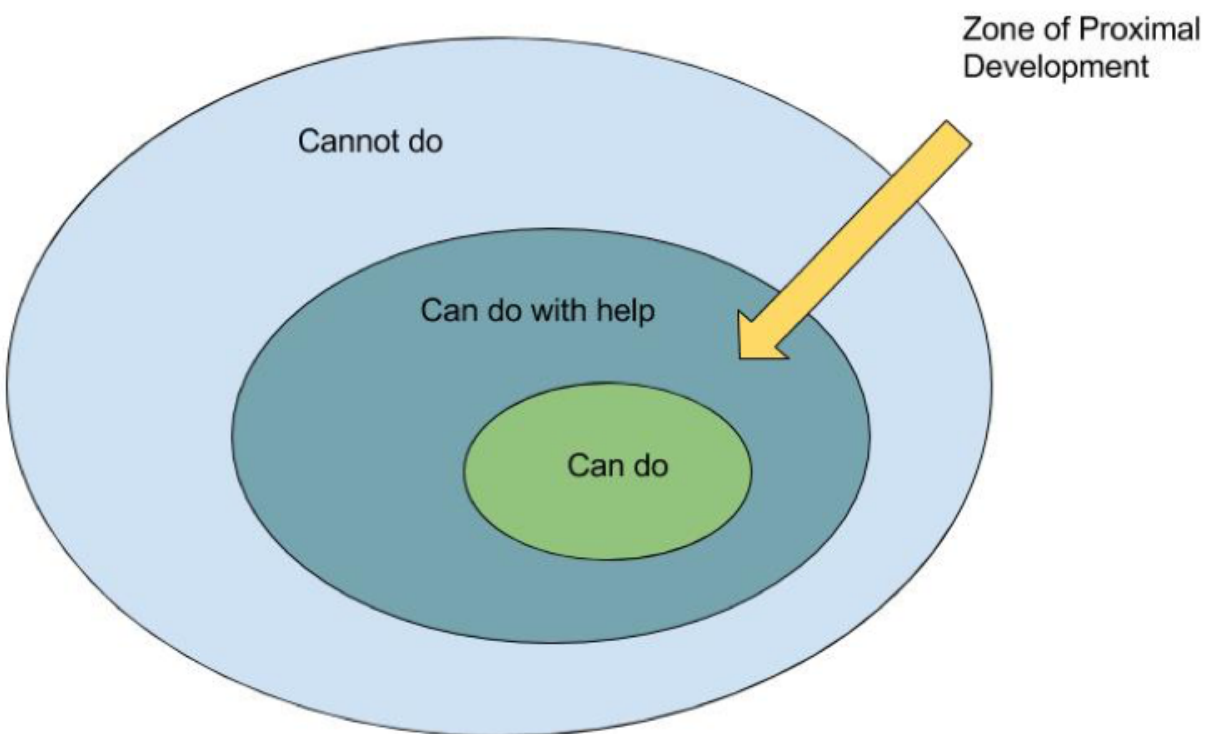
Lev Vygotsky

Lev Vygotsky's work contains a central scope focused on the social aspects of acquiring knowledge. He suggests that one learns best through interacting with others. Through the process of working with others, learners create an environment of shared meanings with peers. By being immersed in the new environment, the learner is able to adapt subjective interpretations to become socially accepted. Vygotsky especially emphasizes that culture plays a large role in cognitive development. He believed infants were born with basic abilities to develop cognitively. Those basic abilities are then enhanced through interaction with others and eventually grow into more sophisticated mental processes. For example, a child is born with the basic ability to memorize. As the child interacts with its environment and peers, the methods of remembrance adapt. If the child is in a learning setting that emphasizes flashcards, the child will use similar methods of repetition to improve memory.

Similar to Piaget's adaptation of radical constructivism from his theory of cognitive development, Vygotsky draws from his own theory of social development. Vygotsky believed that learners could achieve much greater level of learning through the help of a More Knowledgeable Other (instructor). Figure 1 offers a visual of where the instructor can offer the most support and enhance the learning process. The area where the instructor should be most sensitive to guidance is the Zone of Proximal Development (ZPD). As Figure 1 displays, the ZPD straddles the line between what the student already knows and a new concept unable to be mastered without the help of the instructor.

Figure 1

A Graphic Displaying the Pieces of Vygotsky's Social Development Theory



The Zone of Proximal Development is not confined to solely a learner and an instructor. Vygotsky encourages learners to form groups. The formation of groups allows for the less competent children to learn from those who already have

mastered a specific skillset.

John Dewey

John Dewey's perspective melds Piaget's focus on the cognitive aspect of constructivism with Vygotsky's focus on social learning. Susan J. Mayer (2008) contains a synopsis of Dewey's place in constructivism:

Contrary to the assumptions of those who pair Dewey and Piaget based on progressivism's recent history, Dewey shared broader concerns with Vygotsky (whose work he never read). Both Dewey and Vygotsky emphasized the role of cultural forms and meanings in perpetuating higher forms of human thought, whereas Piaget focused on the role played by logical and mathematical reasoning. On the other hand, with Piaget, Dewey emphasized the nurture of independent reasoning central to the liberal Protestant heritage the two men shared. Indeed, Dewey's broad theorizing of democracy's implications for schooling can be seen to integrate the research emphases of the two psychologists (p. 6).

Just as Piaget and Vygotsky did not believe in rote memorization and repetitive lecturing, Dewey's work proclaims that learners who engage in real world activities will be able to demonstrate higher levels of knowledge through creativity and collaboration (Behling & Hart, 2008). One of Dewey's most recognized quotes is: "If you have doubts about how learning happens, engage in sustained inquiry: study, ponder, consider alternative possibilities and arrive at your belief grounded in evidence" (Reece, 2013, p. 320).

Dewey's emphasis on inquiry sustaining learning is sparked best by ensuring a synthesis of environment. Many teachers at the time insisted on keeping school separate from the rest of the children's lives. Dewey did not adhere to the pressure of separation. His research insists that learners need to connect real life experiences with school activities in order to make learning possible.

Learning Theory in Practice

A basic understanding of constructivism requires a clear vision of what it means to allow a learner to connect their own experiences to new knowledge. In order to better illustrate the use of constructivism in the classroom, the next section describes the role of both the learner and the instructor.

Nature of Learner

Throughout the learning process, the learner is expected to consider the information being taught and construct an interpretation. The interpretation is constructed based on past experiences, personal views, and cultural background. Following the interpretation, the learner is expected to reflect on the new knowledge. Radical and social constructivism generally regard the nature of the learner in a similar fashion.

Radical constructivism assumes the learner recognizes their place at the center of the knowledge creation and acquisition process. The learner works through a process of acquisition and assimilation. A major role of the learner is to reflect on past experiences and be conscious of the variables affecting the absorption of the new knowledge. Social constructivism expects similar reflection from the learner, however it also incorporates the social aspects of learning.

Social constructivism not only acknowledges the uniqueness and complexity of the learner, but actually encourages, utilizes and rewards this complexity as an integral part of the learning process. This means that the learner is motivated to reflect on their unique knowledge and allows them to recognize their ability to inspire other learners in their environment. The constant exchange of ideas in the ZPD allows each individual learner to acquire new understandings from their peers. While the learners hold the key to acquiring knowledge in the constructivist framework, the role of instructors is still significant.

Role of Instructor

Due to the nature of constructivism, the instructor must adapt a more hands-on approach instead of the traditional lecture style. The environment of the classroom should be supportive of each individual learner's thinking and encourage a constant challenge.

According to the social constructivist approach, instructors have to adapt to the role of facilitators and not teachers (Bauersfeld, 1995). A facilitator helps the learner to get to his or her own understanding of the content instead of simply explaining a principle. In the latter scenario, the learner does not participate definitively, and in the former scenario, the learner is actively engaged. The goal is thus to turn the emphasis away from the instructor and the content and towards the learner (Gamoran, Secada, & Marrett, 1998). As the emphasis switches to a more active teaching process, the facilitator must act in a different way than a teacher would (Brownstein 2001). As one author explains:

A teacher tells, a facilitator asks; a teacher lectures from the front, a facilitator supports from the back; a teacher gives answers according to a set curriculum, a facilitator provides guidelines and creates the environment for the learner to arrive at his or her own conclusions; a teacher mostly gives a monologue, a facilitator is in continuous dialogue with the learners (Rhodes and Bellamy, 1999).

Examples in Education

There are various examples in the world of education regarding methods of implementation of constructivism. Constructionism, cooperative learning and large-scale lessons are three examples of ways to incorporate constructivism into a classroom.

Constructionism is one application of constructivism. An example of constructionism is an instructor teaching a class of learners about engineering by assigning them to build a bridge. The process the learners would embark on to learn how to build a bridge would in theory teach them all the nuances of engineering concepts. The learning would come mostly through trial and error as the learners adapted their past experiences to the current task.

According to research, cooperative learning is an effective way to implement constructivism in the classroom (Hoy & Woolfolk, 1993). Three examples of cooperative learning are reciprocal questioning, jigsaw classroom and structured controversies. Reciprocal questioning is where students work together to ask and answer questions. This technique is often prevalent through activities such as book discussion groups. Jigsaw classroom refers to assigning students to become experts on one part of a group project and teach it to the others in their group. Structured controversies are where students work together to research a particular controversy.

Another effective implementation of constructivism in the classroom is teaching big topics and allowing each learner to find what pieces relate to them most. For example, an instructor teaching evolution does not choose a specific point in evolution to focus on, but rather gives an overarching explanation. Thus, a student who relates with natural selection is interested in the topic of their own will and chooses to write a paper on it and share with the class.

Criticism and Limitations

Novice learners should have more structure (Jonassen, 1992). According to Bloom's Taxonomy (cf. Fig. 3), the process of learning first starts with remembering and understanding. These two bases require structure to ensure the learner can memorize the subject and recall why the information is important. Without the beginning structure, the learner would struggle to get to the level of application. The lack of structure becomes a possible limitation if the student does not have any base to begin with. However, both Piaget and Vygotsky believe in innate abilities that act as the initial building blocks to learning.

When a group of learners is involved in an activity together, there is a possibility of the learners falling into groupthink (Ruggie, 1998). While not a lot of research has been done on the subject, the author of the chapter suggests that this

may be a limitation which could be further investigated. Those who do not agree with the dominant narrative of a group will not participate as much as those who align with the majority. This is a critique of the implementation, however, and not the theory itself.

Because the nature of constructivism is more abstract and applicable, it is difficult to know if the observed learning outcomes account for everything. Outcomes are generally measured through some form of a rote test and thus do not often incorporate the application and extrapolation of the learning. This could be a limitation of constructivism, if the mode of measurement is not conducive to reflection.

Another possible limitation of constructivism is the time required during implementation. Operating under the constructivist framework, instructors are expected to spend more time engaging the learner. In order to engage the learner, the instructor needs to spend more preparation time out of the classroom thinking about new activities. The instructor also carries the role of allowing time for reflection. Effectively using time can prove to be a problem of constructivism, but it can be fixed through thoughtful implementation.

Conclusion

In conclusion, constructivism is a learning theory which affirms that knowledge is best gained through a process of action, reflection and construction. Piaget focuses on the interaction of experiences and ideas in the creation of new knowledge. Vygotsky explores the importance of learning alongside peers and how culture affects the accommodation and assimilation of knowledge. Dewey emphasizes inquiry and the integration of real world and classroom activities. The constructivist framework relies on the learners to be in control of their own acquisition of knowledge and encourages the instructor to serve as a facilitator. Constructivism has limitations, but it can allow for the learner to reach higher planes of knowledge than would be possible otherwise (Jonassen, 1993).

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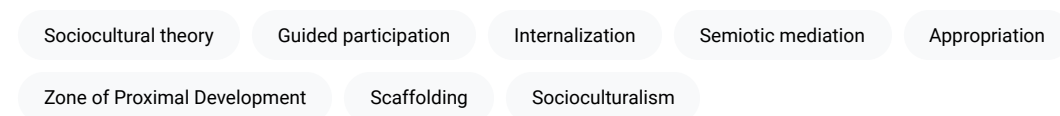


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Socioculturalism

Bohdana Allman



The sociocultural theory of learning and teaching is widely recognized in fields of educational psychology and instructional technology. The focus of this theory is on the role social interaction and culture play in the development of higher-order thinking skills. Vygotsky (1978), a Russian psychologist and the founder of sociocultural theory, believed that human development and learning originate in social and cultural interaction. In other words, the ways people interact with others and the culture in which they live shape their mental abilities.

Sociocultural theory is considered primarily a developmental theory. It focuses on change in behavior over time, specifically on changes that occur as individuals mature from infancy, to childhood, to adolescence, and finally to adulthood. The theory attempts to explain unseen processes of development of thought, of language, and of higher-order thinking skills with implications to education in general and is especially valued in the field of applied linguistics. The theory's focus on a developing child is the reason for referring to a child or children when discussing theoretical underpinnings throughout the text. However, because many implications and practical applications related to sociocultural theory are applicable to learners of all ages, when implications are discussed, the object is generally a learner or learners.

The term sociocultural theory represents a variety of theoretical positions and perspectives. This chapter will briefly introduce the theory's origins, identify the fundamental tenets of the theory with general implications, review strengths and limitations, and discuss implications related to instructional design.

Sociocultural Theory Origins

Origins of sociocultural theory are most closely associated with the work of a Russian psychologist Lev Vygotsky (1896 - 1934). He was a talented scholar with broad interests, an accomplished researcher, and a prolific writer. Vygotsky's goal was "to create a new and comprehensive approach to human psychological processes" (Miller, 2011, p. 168). He was closely familiar with works of his contemporaries such as Pavlov as well as Piaget, Binet, and Freud and often commented on their ideas. His thinking was also influenced by philosophers such as Hegel, Marx, and Engels. He died of tuberculosis at the age of 37, only ten years after his professional career in psychology began (Miller, 2011).

Shortly after Vygotsky's death, his manuscripts were banned in the USSR for political reasons. It was not until the late 1960s when his work was allowed to be published again. Vygotsky first became known in the West when his *Language and Thought* was translated in 1962. His work continues to be disseminated through efforts of scholars such as Cole, Wertsch, John-Steiner, Lantolf, and Rogoff (Miller, 2011). Vygotsky's ideas markedly influenced theories of psychology and education (Driscoll, 2000) and continues to significantly affect educational practices today (Miller, 2011).

Vygotsky's theories are often contrasted with Piaget's theories mainly because both psychologists focused on understanding cognitive processes and development in children. However, their theories were described by Bruner as incommensurate because they highlight "two ways human beings can make sense of their world: by means of logical necessity (Piaget) or by means of interpretive reconstruction of circumstances (Vygotsky)" (Driscoll, 2000, p. 240). Generally, Vygotsky's theories are viewed as complementary to Piaget's and other Western approaches since the broad sociocultural perspective balances the focus on the individual (Miller, 2011).

Fundamental Tenets of the Sociocultural Theory

There are three fundamental concepts that define sociocultural theory: (1) social interaction plays an important role in learning, (2) language is an essential tool in the learning process, and (3) learning occurs within the Zone of Proximal Development. Each idea will be discussed in more detail together with related concepts and implications to learning and education.

Social interaction plays an important role in learning. Vygotsky believed that thinking has social origins and that cognitive development cannot be understood without reference to the social context within which it is embedded. He proposed that social interaction plays a critical role in the process of cognitive development, especially in the development of higher order thinking skills. Social activity between a parent and a child or a teacher and a learner lays a foundation for how and what the child will think and do in other situations (Driscoll, 2000).

Vygotsky wrote: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first between people (interpsychological) and then inside the child (intrapsychological)" (Vygotsky, 1978, p. 57). This process is characterized as guided participation where a child actively acquires new cognitive skills and problem-solving capabilities through a meaningful collaborative activity with an assisting adult (Rogoff, 1990). It is through working together on a variety of tasks that a learner internalizes or adopts socially shared experiences and associated effects and acquires useful strategies and knowledge (John-Steiner & Mahn, 1996; Scott & Palincsar, 2013). The processes of guided participation and internalization reveal the Vygotskian view of cognitive development "as the transformation of socially shared activities into internalized processes," or an act of enculturation, thus rejecting the Cartesian dichotomy between the internal and the external (John-Steiner & Mahn, 1996, p. 192).

Vygotsky's notion of social origins of learning stand in stark contrast to more popular views of Piaget's theory of cognitive development, who made a fundamental assumption that development through certain stages is biologically determined, originates in the individual, and precedes cognitive complexity. This difference in assumptions is significant, as it has important implications to learning and education. If "development is a precondition for learning," as Piaget states, then concepts and problems "should not be taught until children have developed the necessary logical operations to understand them" (Driscoll, 2000, p. 249). If we believe, as Vygotsky did, that learning drives development and that "development occurs as children learn general concepts and principles that can be applied to new tasks and problems," then we can structure curriculum and activities to actually promote individual student learning and development (Scott & Palincsar, 2013, par. 8). As children learn, they achieve a higher level of development, which in turn "affects their readiness to learn a new concept" (Miller, 2011, p. 197). In Vygotsky's own words:

Learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and with his peers... learning is not development; however, properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning. Thus learning is a necessary and universal aspect of the process of developing culturally organized, specifically human, psychological functions (1978, p. 90).

Another implication based on the Vygotskian view of learning originating in social and historical contexts is that the sociocultural perspective acknowledges both individual differences and cross-cultural differences in development. This "sensitivity to diversity is quite important" because much of research and the resulting understanding of development is done on white, middle-class children of Western tradition and assumes universality (Miller, 2011, p. 198). Recognizing

that “ideal thinking and behavior may differ for different cultures” and that “different historical and cultural circumstances may encourage different developmental routes to any given developmental endpoint” may liberate educators from a constricting universalist view and allow them to provide a nurturing environment where diversity is valued as a resource (Miller, 2011, p. 198).

Language is an essential tool in the learning process. The second important notion on which Vygotsky elaborated is related to the role of language in the learning process. Vygotsky reasoned that social structures determine people's working conditions and social interactions, which in turn shape their cognition, beliefs, attitudes, and perception of reality (Miller 2011). He extended his reasoning further with a notion that human action on both the social and individual planes is mediated by tools and signs, or semiotics, such as language, systems of counting, conventional signs, works of art, etc. Vygotsky suggested that through the use of these tools, or semiotic mediation, co-construction of knowledge is facilitated and social and individual functioning is mediated. These semiotic means play an important role in development and learning through appropriation, a process of adopting or internalizing these socially available psychological tools by an individual to assist future independent problem solving (John-Steiner & Mahn, 1996). This means that children and learners do not need to reinvent already existing tools in order to be able to use them. They only need to be introduced to how a particular tool is used and then they can use it across a variety of situations, including novel events (Scott & Palincsar, 2013).

Vygotsky viewed language as a direct result of the symbols and tools that emerge within a culture. It is potentially the greatest tool at our disposal, a form of a symbolic mediation that plays two critical roles in development: to communicate with others and to construct meaning (McLeod, 2014). First, language is used to assign meaning during social interaction to facilitate communication in social settings. This occurs as a child engages in the environment and through a variety of social events and processes acquires language of their closest community, the family. Generally, this so called social speech emerges around age two, and it is a form of an external or over speech directed toward others with a communicative function (McLeod, 2014). A child discovers that words have meaning, realizes that this meaning is shared within the language community, and begins to use these words to communicate with others to fulfill their needs. During this process of development a child also internalizes the tone of voice, the way concepts are talked about, and the signs and symbols used to attach value to things and events, which eventually shape value sets of that individual (Miller, 2011; Tharp, 2001). Vygotsky believed that language and thought are two separate systems at this initial stage (Vygotsky, 1986).

The other role of language is that it aids in construction of understanding. It is a powerful tool of intellectual development and adaptation. Around age three, children begin to develop what is referred to as private speech. This is an external or overt language, just as social speech, but it is directed to self. Furthermore, private speech serves intellectual and self-regulating functions rather than a communicative function (McLeod, 2014; Vygotsky, 1986). This can be visible as a child voices thoughts aloud, especially while solving difficult problems or challenging tasks. They use language to plan out a strategy, organize thoughts, or collaborate with themselves as they would with a more knowledgeable other. In this way, private speech is not just a part of a child's activity, but it becomes a tool used by the child to facilitate their own cognitive processes and development (Miller, 2011). According to Vygotsky, at about age three language and thought begin to merge from two separate systems and become interdependent: thoughts become verbal and speech becomes representational (McLeod, 2014).

Transformation of private speech into inner speech is a gradual process. It is around age seven when private speech becomes less visible, a child's monologue internalizes, and private speech becomes inner speech. A child is able to 'think in words.' Vygotsky explained that while external speech is embodied thought in words, inner speech is more idiosyncratic, abbreviated, and fragmented, and it is “to a large extent thinking in pure meanings” (1986, p. 249). Inner speech, just like private speech, remains directed at self and retains self-regulating and intellectual functions, however, it is covert and inaudible (McLeod, 2014). This internalization of language is important, because it drives cognitive development. Inner speech takes the form of ideas that remain within our minds and directly impacts our thoughts, behaviors, and the development of higher order thinking skills.

Vygotsky thought that private speech is strongly affected by an individual's social environment, which has been supported by high correlations between social interaction and private speech observed in children (McLeod, 2014). Children from higher socioeconomic backgrounds are often raised in cognitively and linguistically more stimulating environments, and they tend to begin using and internalizing private speech faster than their less privileged peers (McLeod, 2014). This brings interesting implications to education. Supportive educational environments, especially during early elementary grades can provide additional cognitive and linguistic support and modeling of academic monologue, which may positively affect development of private and inner speech for children of all economic backgrounds and may in turn positively support their cognitive development and academic performance.

Learning occurs within the zone of proximal development. Probably the most widely adopted concept related to sociocultural theory is the concept of the Zone of Proximal Development (ZPD). It is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). It is essentially the zone where learning takes place. Vygotsky strongly believed that learning should be matched with a child's developmental level and suggested that in order to understand the connection between development and learning it is necessary to distinguish the actual and the potential levels of development. He considered the ZPD to be a better and more dynamic indicator of cognitive development as compared to merely measuring what children can accomplish independently (Scott & Palincsar, 2013).

Vygotsky viewed the application of ZPD broadly, referring to "any situation in which some activity is leading children beyond their current level of functioning. Thus the zone can operate during play, work, school studies, and other ... activities" (Miller, 2011, p. 178). He argued that productive interactions "orient instruction toward the ZPD; otherwise, instruction lags behind the development of the child" (Scott & Palincsar, 2013, par. 8). Providing sensitive instruction and guidance within the ZPD allows a learner to develop skills and strategies they will eventually apply on their own in other situations, which is characteristic of developing higher cognitive skills (Vygotsky, 1978). The role of a learner's social partner is also critical since the type of social interactions, tools they use, and skills they practice determine the outcome of the collaborative experience, which could lead to a normal and accelerated development as well as to developmental delays and an abnormal development (Driscoll, 2011). Thus an ideal partner, whether an adult or a peer, should be advanced enough in knowledge or skill to promote learning and at the same time be able to interact within the zone not too far beyond the learner's reach. Additionally, partners in a successful collaborative activity share a degree of common understanding about the task, a common goal, described as intersubjectivity. It is not sufficient for the partners to merely work together, they must co-construct the problem's solution through coordinated effort, which implies shared power and authority over the process (Driscoll, 2011).

In the 1970s, Bruner, Wood and Ross added the notion of scaffolding to sociocultural theory (Puntambekar, 2009). Scaffolding is the support mechanism that helps a learner successfully complete a task within ZPD and as such is the practical tool in actualizing guided participation. Scaffolding describes an ongoing support provided to a learner by an expert in a process of learning and completing a task they cannot complete without assistance. It connotes a mutual and dynamic nature of interaction where both the learner and the expert influence each other and adjust their behavior as they collaborate (Miller, 2011). Similar to a way physical scaffolding provides both adjustable and temporary support to buildings under construction, scaffolding in a sociocultural context refers to a more skilled other providing a learner with necessary support as their emerging skills develop. These supports depend on the learner's needs and are gradually phased out as the learner become proficient, thus promoting movement toward autonomy (Miller, 2011). Scaffolding involves an expert knowledgeable about both content and pedagogy being able to adapt the task to the learner's ability. The expert motivates and guides the learner by providing just enough assistance, modeling, and highlighting critical features of the task as well as continually evaluating and adjusting supports as needed. Additionally, the expert facilitates reflection through suggestions and questions, which further promotes more complex, meaningful, and lasting learning experiences (Puntambekar, 2009).

Concepts of ZPD and scaffolding have quite revolutionary implications to assessment, instruction, and education in general. Traditionally, assessment measures what learners know and understand unaided at a given point of time. However, as briefly mentioned above, Vygotsky believed that taking into account both what a learner knows

independently and what they can do or understand with assistance is a more accurate measure of that individual's learning. So-called dynamic assessment reveals performance improvements that are often not recognized by standard assessments and testing, which is especially apparent in underachieving children who commonly do not perform to their ability levels (Miller, 2011). Understanding what a child can accomplish without as well as with assistance can inform educators and other stakeholders, and it can also significantly improve quality and effectiveness of instruction.

Furthermore, sociocultural theory suggests a different dynamic for the relationship between the learner and the teacher than is currently typical in a school setting. The learner takes on more responsibilities such as determining their learning goals, becoming a resource of knowledge for peers, and being collaborators in the learning process. The teacher is viewed as a guide, an assistant, and a facilitator of learning rather than a transmitter of knowledge or an enforcer of rules (Grabinger, Aplin, & Ponnappa-Brenner, 2007). This shift in roles promotes individualized, differentiated, and learner-centered types of instruction, which when accompanied with effective pedagogical practices provides a powerful alternative for reforming current educational systems and creating environments that may "make it possible for the majority of individuals to develop deep understanding of important subject matters" (Watson & Reigeluth, 2016, par. 13, quoting Bransford et al., 1999, p. 6).

Strengths and Limitations of Sociocultural Theory

Sociocultural theory has several widely recognized strengths. First, it emphasizes the broader social, cultural, and historical context of any human activity. It does not view individuals as isolated entities, rather it provides a richer perspective focusing on the fluid boundary between self and others. It portrays the dynamic of a child acquiring knowledge and skills from the society and then in turn the child shaping their environment (Miller, 2011). Second, sociocultural theory is sensitive to individual and cross-cultural diversity. In contrast to many developmental theories that focus on universal aspects of development, sociocultural theory acknowledges both differences in individuals within a culture and differences in individuals across cultures. It recognizes that "different historical and cultural circumstances may encourage different developmental routes to any given developmental endpoint" depending on particular social or physical circumstances and tools available (Miller, 2011, p. 198). Finally, sociocultural theory integrates the notion of learning and development greatly contributing to our theoretical understanding of cognitive development. The idea of learning driving development rather than being determined by a developmental level of the learner fundamentally changes our understanding of the learning process and has significant instructional and educational implications (Miller, 2011).

There are also limitations to the sociocultural perspective. The first limitation is related to Vygotsky's premature death as many of his theories remained incomplete. Furthermore, his work was largely unknown until fairly recently due to political reasons and issues with translation. The second major limitation is associated with the vagueness of the ZPD. Individuals may have wide or narrow zones, which may be both desirable and undesirable, depending on the circumstances. Knowing only the width of the zone "does not provide an accurate picture of their learning, ability, style of learning, and current level of development compared to other children of the same age and degree of motivation" (Miller, 2011, p. 198). Additionally, there is little known about whether a child's zone is comparable across different learning domains, with different individuals, and whether the size of the zone changes over time. There is also not a common metric scale to measure ZPD (Miller, 2011). Finally, Rogoff points out that Vygotsky's theories may not be relevant to all cultures as originally thought. She provides an example of scaffolding being heavily dependent on verbal instruction and thus not equally effective in all cultures for all types of learning (McLeod, 2014; Rogoff, 1990).

Instructional Design Implications

So far this chapter has highlighted some important implications of sociocultural theory, which are generally applicable to instruction, assessment, and education. This section will review additional implications taking into considerations issues specifically related to the field of instructional design. Sociocultural theory is not commonly associated with instructional design methods. These methods traditionally rely on individualistic learning driven by set learning

objectives and strands of often context-deprived topics being presented in a logical and structured sequence. Generally there is little or no consideration for already existing knowledge, relationships, or cultural richness. Systematic approaches to instructional design, often rooted in behaviorist theory, may be valuable for “teaching concepts, procedures and basic skills” (Grabinger, Aplin, & Ponnappa-Brenner, 2007, p.1). But Grabinger, Aplin, and Ponnappa-Brenner (2007) further propose that in order to

meet the goal of ‘preparing people for an ever-changing world’, instructional programs need to apply strategies that focus on the development of critical thinking, problem solving, research, and lifelong learning... (, which) require a sociocultural approach to instruction emphasizing learning from experience and discourse (p. 1).

Three major implications of sociocultural theory to instructional design will be discussed as a reaction to the above description of traditional instructional design. These include: focus on the individual learner, use of effective pedagogies centered around collaborative practice and communities of learners, and attention to funds of knowledge.

Most instructional design models, such as ADDIE, take into consideration only the common learner, tying learning with concrete and measurable objectives. Recently, a strong call has been issued for a complete shift in our education and instructional design approaches requiring a learner-centered instruction to reflect our society’s changing educational needs (Watson & Reigeluth, 2016). New methodologies, such as Universal Design for Learning based in the learning sciences recognize that every learner is unique and strive to provide challenging and engaging curricula for diverse learners. Watson and Reigeluth (2016) mention that there are two important features of learning-centered instruction: a focus on the individual learner and a focus on effective learning practices. Sociocultural theory and related methodologies may provide a valuable contribution to this effort as they focus on a learner in their social, cultural, and historical context and also offer sound pedagogical solutions and strategies that facilitate development of critical thinking and encourage lifelong learning (Grabinger, Aplin, & Ponnappa-Brenner, 2007).

Sociocultural theory allows instructional designers to apply principles of collaborative practice that go beyond social constructivism and create effective communities of learners through effective pedagogies. The sociocultural perspective views learning taking place through interaction, negotiation, and collaboration in solving authentic problems while emphasizing learning from experience and discourse, which is more than cooperative learning. This is visible, for example, in situated learning theory and cognitive apprenticeship. In addition to the collaborative nature of learning, approaches grounded in sociocultural theory pay attention to and model the discourse, norms, and practices associated with a certain community in order to develop knowledge and skills important to that community (Scott & Palincsar, 2013). This approach is consistent with communities of practice and inquiry-based methods, which enculturate learners into the community of practice, highlighting the importance of effective pedagogical practices, quality of content, as well as strong social presence to increase the effectiveness of learning experiences and successfully facilitate critical thinking and higher-order learning outcomes (Garrison & Akyol, 2013). Furthermore, the emergence of new synchronous and asynchronous communication technologies and increased attention to computer-supported collaborative learning (CSCL) create new opportunities for applying sociocultural methodologies as their affordances allow quality collaboration and new ways of interacting in face-to-face, blended, and online environments (Garrison & Akyol, 2013).

Lastly, current instructional methodologies generally do not give much consideration for existing knowledge, established relationships, or cultural richness, commonly referred to as a learner’s funds of knowledge. Garrison and Akyol (2013) explained that when social presence is established as part of a community of inquiry, which requires recognition and use of these funds of knowledge, “collaboration and critical discourse is enhanced and sustained” (p. 108). Establishment of solid social presence further reflects in positive learning outcomes, increased satisfaction, and improved retention (Garrison & Akyol, 2013). Integrating sociocultural practices into learning design, for example through creation of communities of inquiry, spontaneously integrates a learner’s previous knowledge, relationships, and cultural experiences into the learning process and enculturate the learner into the new community of practice through relevant activities and experiences (Grabinger, Aplin, & Ponnappa-Brenner, 2007). Another interesting solution to supporting social and cognitive factors in learning is the creation of a third space for discourse where a learner’s primary discourse related to home and informal social interactions is merged with the secondary formal discourse of school. This allows students to share in less formal environments, which lowers the affective filter, encourages

exchanges, and gives students control over when, how, and what to share. Third-space discourse also encourages educators to recognize students' personal experiences and to incorporate their students' funds of knowledge into instruction, which results in increased conceptual understanding and use of academic language (Scott & Palincsar, 2013). When learners feel valued as participants in the community, when their prior experiences and knowledge are recognized and integrated into learning experiences, and when instruction reflects culturally sensitive practices, their motivation and satisfaction increases, and learning becomes deeper, lasting, and more meaningful.

Conclusion

The notion of social origins of learning, the interrelationship of language and thought, and the notion of ZPD are Vygotsky's most important contributions. However, it is the practical applications of sociocultural theory that create learner-centered instructional environments where learning by discovery, inquiry, active problem solving, and critical thinking are fostered through collaboration with experts and peers in communities of learners and encourage self-directed lifelong learning habits. Presenting authentic and cognitively challenging tasks within a context of collaborative activities, scaffolding learner's efforts by providing a structure and support to accomplish complex tasks, and providing opportunities for authentic and dynamic assessment are all important aspects of this approach. Sociocultural principles can be applied in effective and meaningful ways to design instruction across the curriculum, for learners of different ages and variety of skills, and it can be effectively integrated using a wide range of technologies and learning environments. The challenge remains for educators and instructional designers to elevate our practices from efficient systemic approaches for teaching and instructional design to focusing on individual learners and effective pedagogical practices to develop empowered learners ready to successfully negotiate the rapidly changing era of information. Technology is at our fingertips, it is up to us to competently implement its unique affordances to promote new ways to educate and support deep, meaningful, and self-directed learning. Grounding our practices in sociocultural theory can significantly aid our efforts.

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Bohdana Allman

Bohdana Allman is an educator, researcher, and learning experience designer. Her work focuses on designing and implementing online collaborative teacher professional development grounded in sociocultural principles and communities of practice. Her research interests include actively engaging learners from diverse backgrounds, facilitating close collaboration and dialogue within professional communities, integrating learning with practice, and fostering reflection.

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Case Studies

Alyssa Erickson

Research Methods

Case Study

Cross-case Analysis

Qualitative Methods

Imagine your childhood neighborhood. Retrace the steps that you would take each day to play outside, visit friends, or simply explore. Perhaps there are many experiences that you dwell on, such as the place where you crashed your bike, the smell of cookies at your neighbor's house, or the distance you ran when you raced your friends around the block. If you were to write a short story, in order to provide enough depth you would likely need to focus on just one aspect of your childhood experience in that neighborhood. Wilson (1996) remarks that an environment as rich as this has varying dimensions such as constancy and change, simplicity and complexity; you knew your way around in the neighborhood, but there was always more to find. The same is true for case studies in educational research. Case studies are a qualitative research method that focus on one unit of study (Merriam, 1998). This chapter seeks to clearly define case studies, explore their weaknesses and strengths, and discuss when and for what research questions they are most appropriate to use as an educational research method.

Defining a Case Study

In the book *The Art of Case Studies*, Robert E. Stake (1995) defines case study as “the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances” (p. xi). Like other qualitative research methods, case studies provide a holistic view of their context. Case studies use a variety of qualitative research methods, such as observations and interviews, to provide rich detail. This rich detail makes case studies a useful tool for instruction and discussion in many subjects, such as business, law, and the social sciences, which includes education. Just like the example of your childhood neighborhood, case studies look closely at a slice of life.

Types of Case Studies

According to Merriam (1998), the types of case studies in educational research can be separated into four main categories: (1) ethnographic, (2) historical, (3) psychological and (4) sociological. In short, ethnographic case studies focus on how people behave in cultural settings, such as the culture within a classroom. Historical case studies use a variety of evidences to understand a context over time, such as the founding and development of a private school. Psychological case studies, such as studies by Piaget on his own children, look at individuals and analyze their behavior. Sociological case studies focus on social constructs and use demographics to analyze the case, such as socioeconomic differences within a school (Merriam, 1998).

Importance of Boundaries

In her widely-cited book *Qualitative Research and Case Study Applications in Education*, Sharan B. Merriam (1998) remarks that “the most single defining characteristic of case study research lies in delimiting the object of study, the

case” (p. 27). Boundaries require researchers to scope their study. Researchers choose a bounded context which can contain a person, an organization, a class, a policy, or any given unit of study. Boundaries also help a researcher to define what will not be included in the study. If a researcher cannot state a limit to the number of participants or the amount of time their research requires, then it does not qualify as a case study (Merriam, 1998). Continuing with the example of your childhood neighborhood, you would need to decide what phenomenon in the neighborhood to focus on. If you chose to study the types of interactive play that occur in the neighborhood park, you would need to specify a length of time for the study and limit your observations to only what occurs in the boundaries of the park.

Weaknesses of Case Studies

Many critiques of case studies align with critiques of qualitative research methods in general. These include the time-consuming nature of data collection and analysis, the increased risk of researcher bias, and the lack of generalizability that could influence credibility (Johnson & Onwuegbuzie, 2004). As mentioned previously, case studies use a variety of qualitative research techniques, which often require a researcher to spend large amounts of time collecting data, finding the appropriate way to code and organize data, and analyzing the data to make sound conclusions. Some critics remark that qualitative research methods are more susceptible to data cherry-picking, when a researcher only presents evidence that matches their own position. Some are concerned that qualitative research is more susceptible to a researcher’s assumptions and biases. Frequently, policy-makers, administrators, and other leaders look to quantitative data for decision-making and view qualitative data as being too specific to just one context. This is perhaps the weakness that is most relevant to case studies.

Due to the boundaries that define a case study, the sample size for research is often small. Over-simplification and exaggeration can mislead a reader to think that a case study represents a greater part of the whole than is true (Merriam, 1998). Research with a smaller scope and sample size cannot find patterns across a wide sampling of cases, making it less generalizable. Data from a small sampling of participants may be dismissed as an outlier or as being unique to that specific group (Johnson & Onwuegbuzie, 2004). In contrast, quantitative data uses inferential statistics to find patterns and generalizable cases, which often speak to decision-makers because they appear to be more applicable to their own situation.

Strengths of Case Studies

Despite the common critiques of case studies outlined previously, the rich and holistic detail provided by case study has many advantages for researchers and other stakeholders. Complexities of a phenomenon within one case or context should be analyzed in depth, which requires time to observe, describe, and analyze. Other research methods would not provide this depth and detail, because they have a larger scope, which may limit them to collect more superficial data. Provided that a researcher is using appropriate techniques to collect and analyze data, the time is well spent to understand the context, because the resulting detail increases usefulness and transferability. Additionally, proper qualitative research always uses multiple methods to establish trustworthiness that acknowledges and reduces bias in a study, such as member checking or triangulation from multiple data sources. Like other qualitative methods, case studies are responsive to changes during the course of study and to the needs of the stakeholders (Johnson & Onwuegbuzie, 2004). This is especially true in case study, because the researcher is often immersed in the context, giving them a greater understanding of how to adapt. Additionally, case studies are frequently used to improve their own context, such as an evaluation of an educational program.

Case studies are not only valuable to the stakeholders within its bounded context; their rich detail makes them transferable to other contexts. Sometimes the generalizable knowledge produced from quantitative research is so broad and abstract that it is not useful to specific contexts (Johnson & Onwuegbuzie, 2004). Qualitative research as a whole does not seek to be generalizable; its value lies in its transferability. Generalizable research aims to apply its findings to the population at large, whereas transferable research must be applied by the reader as they make connections between the research and their own experiences. Transferability to other contexts can come from

descriptions of decisions, structures, findings, and other principles found in the case. A reader may see connections to their own context that inform their thinking or decision-making. Perhaps they decide to avoid a course of action, because the case study showed that it did not work for one context, or they see how they can adapt their approach based on positive results in the case study. Rich detail is necessary for this kind of transferability.

Cross-Case Analysis

Also called collective, multicase, or comparative case studies, a cross-case analysis looks for similarities and differences between multiple case studies (Merriam 1998). Although a standard case study may have subunits, such as multiple students in a classroom, a cross-case analysis generally takes on a larger scope, such as multiple classrooms or multiple schools. A compelling cross-case analysis includes more cases and greater variety between the cases. Cross-case analysis requires rigorous comparison and interpretation, which strengthens the preciseness and stability of the research (Merriam 1998). The external validity, or generalizability, increases when patterns are found across cases because the sample size increases and the case results either confirm or negate each other. Thus, a researcher may choose to conduct a cross-case analysis if they plan to select and research multiple cases. Though the goal of the cross-case analysis is still transferability, this will increase the generalizability of the research results.

When to Use Case Studies

With the strengths and weaknesses of case studies in mind, I will now discuss when it is most appropriate to use case study as a qualitative research method in education. Recall that the most defining characteristic of a case study is its boundaries. It follows that a researcher should use case study as their research method when it is feasible and advantageous to set clear limits around their research. A case study is a method that suits many beginning researchers, because the scale is small and the context is focused. However, case studies should not be overly simplistic nor a mere description of what happens; like any research in education, they should be a worthwhile addition to the current literature (Rowley, 2002). This requires the researcher to know what is currently in the literature regarding the topic and where stronger evidence is needed or gaps in knowledge exist.

A research question should not be altered to fit a chosen research method; rather, a research method such as case study should be based on the research question. Case studies are particularly useful as preliminary research that provides a fresh perspective and sets the stage for future, related research. However, case studies can stand alone by rigorously describing and explaining a phenomenon (Rowley, 2002). Case studies answer “how” and “why” research questions with a high degree of detail. More specifically, case studies fit well when “a how or why question is being asked about a contemporary set of events over which the investigator has little or no control” (Yin, 1994, p. 9). For example, in my current case study research the questions I seek to answer have to do with how an organization has adopted a specific instructional design method to their context, why they have adopted it to that degree, and how that method has influenced the perceived quality of courses, the speed at which they are produced, and employee satisfaction. Note that the scope in these questions refers to only what is going on in the organization. Case study is a suitable method to answer these bounded research questions.

Conclusion

Just as it is compelling to attempt to describe one aspect of your childhood neighborhood, case studies are a valuable way of looking at the world, because they allow a researcher to set boundaries and focus on one unit of study. Although case studies are susceptible to common criticisms of qualitative research methods like small sample size, the rich detail they provide help to make them a learning tool that produces knowledge that is transferable to other contexts. Conducting a cross-case analysis would increase generalizability, because it seeks to find patterns across multiple cases. Case study should be selected for research questions that have an appropriate, bounded scope and seek to answer “how” and “why questions.” The fact that case studies are well-suited for beginning researchers does not

diminish the importance of rigor or their value in educational research. Case studies are a useful research method in many fields, particularly education, because a holistic view within a bounded context brings about rich detail, which enhances the understanding of the researcher and reader alike.

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Design-Based Research

Matthew Armstrong, Cade Dopp, & Jesse Welsh

In an educational setting, design-based research is a research approach that engages in iterative designs to develop knowledge that improves educational practices. This chapter will provide a brief overview of the origin, paradigms, outcomes, and processes of design-based research (DBR). In these sections we explain that (a) DBR originated because some researchers believed that traditional research methods failed to improve classroom practices, (b) DBR places researchers as agents of change and research subjects as collaborators, (c) DBR produces both new designs and theories, and (d) DBR consists of an iterative process of design and evaluation to develop knowledge.

Origin of DBR

DBR originated as researchers like Allan Collins (1990) and Ann Brown (1992) recognized that educational research often failed to improve classroom practices. They perceived that much of educational research was conducted in controlled, laboratory-like settings. They believed that this laboratory research was not as helpful as possible for practitioners.

Proponents of DBR claim that educational research is often detached from practice (The Design-Based Research Collective, 2002). There are at least two problems that arise from this detachment: (a) practitioners do not benefit from researchers' work and (b) research results may be inaccurate, because they fail to account for context (The Design-Based Research Collective, 2002).

Practitioners do not benefit from researchers' work if the research is detached from practice. Practitioners are able to benefit from research when they see how the research can inform and improve their designs and practices. Some practitioners believe that educational research is often too abstract or sterilized to be useful in real contexts (The Design-Based Research Collective, 2002).

Not only is lack of relevance a problem, but research results can also be inaccurate by failing to account for context. Findings and theories based on lab results may not accurately reflect what happens in real-world educational settings.

Conversely, a problem that arises from an overemphasis on practice is that while individual practices may improve, the general body of theory and knowledge does not increase. Scholars like Collins (1990) and Brown (1992) believed that the best way to conduct research would be to achieve the right balance between theory-building and practical impact.

Paradigms of DBR

Proponents of DBR believe that conducting research in context, rather than in a controlled laboratory setting, and iteratively designing interventions yields authentic and useful knowledge. Sasha Barab (2004) says that the goal of DBR is to "directly impact practice while advancing theory that will be of use to others" (p. 8). This implies "a pragmatic philosophical underpinning, one in which the value of a theory lies in its ability to produce changes in the world" (p. 6). The aims of DBR and the role of researchers and subjects are informed by this philosophical underpinning.

Aims of DBR

Traditional, experimental research is conducted by theorists focused on isolating variables to test and refine theory. DBR is conducted by designers focused on (a) understanding contexts, (b) designing effective systems, and (c) making meaningful changes for the subjects of their studies (Barab & Squire, 2004; Collins, 1990). Traditional methods of research generate refined understandings of how the world works, which may indirectly affect practice. In DBR there is an intentionality in the research process to both refine theory and practice (Collins et al., 2004).

Role of DBR Researcher

In DBR, researchers assume the roles of “curriculum designers, and implicitly, curriculum theorists” (Barab & Squire, 2004, p.2). As curriculum designers, DBR researchers come into their contexts as informed experts with the purpose of creating, “test[ing] and refin[ing] educational designs based on principles derived from prior research” (Collins et al., 2004, p. 15). These educational designs may include curricula, practices, software, or tangible objects beneficial to the learning process (Barab & Squire, 2004). As curriculum theorists, DBR researchers also come into their research contexts with the purpose to refine extant theories about learning (Brown, 1992).

This duality of roles for DBR researchers contributes to a greater sense of responsibility and accountability within the field. Traditional, experimental researchers isolate themselves from the subjects of their study (Barab & Squire, 2004). This separation is seen as a virtue, allowing researchers to make dispassionate observations as they test and refine their understandings of the world around them. In comparison, design-based researchers “bring agendas to their work,” see themselves as necessary agents of change and see themselves as accountable for the work they do (Barab & Squire, 2004, p. 2).

Role of DBR Subjects

Within DBR, research subjects are seen as key contributors and collaborators in the research process. Classic experimentalism views the subjects of research as things to be observed or experimented on, suggesting a unidirectional relationship between researcher and research subject. The role of the research subject is to be available and genuine so that the researcher can make meaningful observations and collect accurate data. In contrast, design-based researchers view the subjects of their research (e.g., students, teachers, schools) as “co-participants” (Barab & Squire, 2004, p. 3) and “co-investigators” (Collins, 1990, p. 4). Research subjects are seen as necessary in “helping to formulate the questions,” “making refinements in the designs,” “evaluating the effects of...the experiment,” and “reporting the results of the experiment to other teachers and researchers” (Collins, 1990, pp. 4-5). Research subjects are co-workers with the researcher in iteratively pushing the study forward.

Outcomes of DBR

DBR educational research develops knowledge through this collaborative, iterative research process. The knowledge developed by DBR can be separated into two categories: (a) tangible, practical outcomes and (b) intangible, theoretical outcomes.

Tangibles Outcomes

A major goal of design-based research is producing meaningful interventions and practices. Within educational research these interventions may “involve the development of technological tools [and] curricula” (Barab & Squire, 2004, p. 1). But more than just producing meaningful educational products for a specific context, DBR aims to produce meaningful, effective educational products that can be transferred and adapted (Barab & Squire, 2004). As expressed by Brown (1992), “an effective intervention should be able to migrate from our experimental classroom to average classrooms operated by and for average students and teachers” (p.143).

Intangible Outcomes

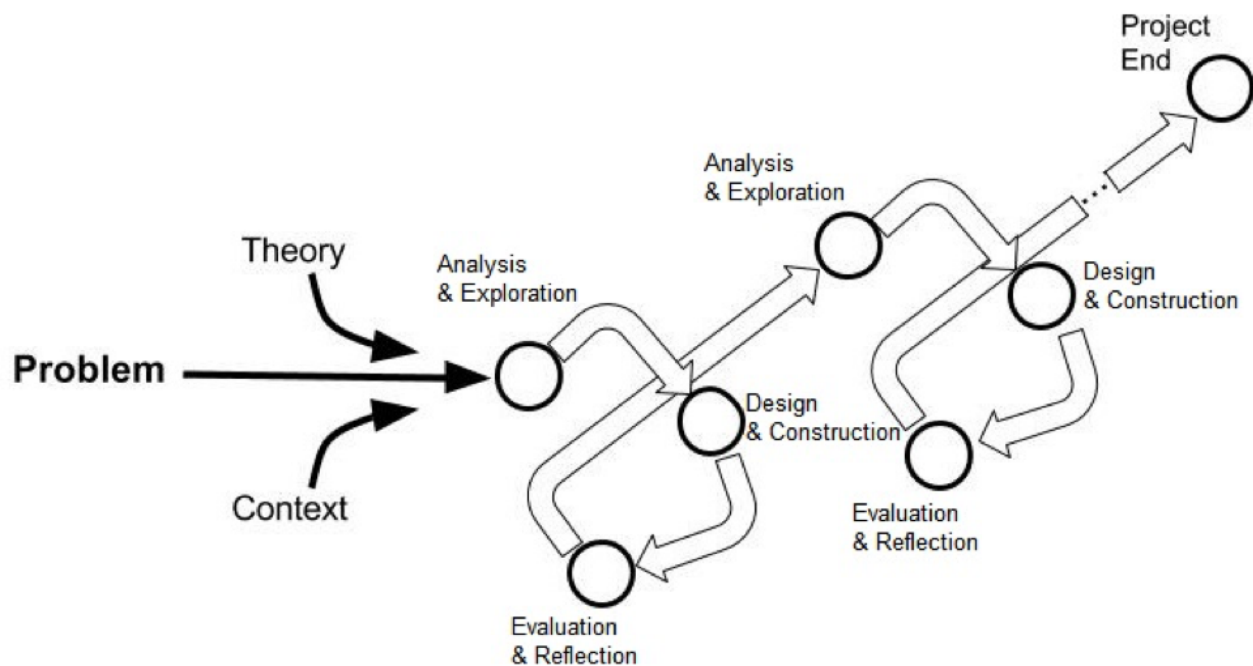
It is important to recognize that DBR is not only concerned with improving practice but also aims to advance theory and understanding (Collins et al., 2004). DBR's emphasis on the importance of context enhances the knowledge claims of the research. "Researchers investigate cognition in context...with the broad goal of developing evidence-based claims derived from both laboratory-based and naturalistic investigations that result in knowledge about how people learn" (Barab & Squire, 2004, p.1). This new knowledge about learning then drives future research and practice.

Process of DBR

A hallmark of DBR is the iterative nature of its interventions. As each iteration progresses, researchers refine and rework the intervention drawing on a variety of research methods that best fit the context. This flexibility allows the end result to take precedence over the process. While each researcher may use different methods, McKenny and Reeves (2012) outlined three core processes of DBR: (a) analysis and exploration, (b) design and construction, and (c) evaluation and reflection. To put these ideas in context, we will refer to a recent DBR study completed by Siko and Barbour regarding the use of PowerPoint games in the classroom.

Figure 1

The Iterative Process of Design-Based Research



Analysis and Exploration

Analysis is a critical aspect of DBR and must be used throughout the entire process. At the start of a DBR project, it is critical to understand and define which problem will be addressed. In collaboration with practitioners, researchers seek to understand all aspects of a problem. Additionally, they "seek out and learn from how others have viewed and solved similar problems" (McKenny & Reeves, 2012, p. 85). This analysis helps to provide an understanding of the context within which to execute an intervention.

Since theories cannot account for the variety of variables in a learning situation, exploration is needed to fill the gaps. DBR researchers can draw from a number of disciplines and methodologies as they execute an intervention. The decision of which methodologies to use should be driven by the research context and goals.

Siko and Barbour (2016) used the DBR process to address a gap they found in research regarding the effectiveness of having students create their own PowerPoint games to review for a test. In analyzing existing research, they found studies that stated teaching students to create their own PowerPoint games did not improve content retention. Siko and Barbour wanted to “determine if changes to the implementation protocol would lead to improved performance” (Siko & Barbour, 2016, p. 420). They chose to test their theory in three different phases and adapt the curriculum following each phase.

Design and Construction

Informed by the analysis and exploration, researchers design and construct interventions, which may be a specific technology or “less concrete aspects such as activity structures, institutions, scaffolds, and curricula” (Design-Based Research Collective, 2003, pp. 5–6). This process involves laying out a variety of options for a solution and then creating the idea with the most promise.

Within Siko and Barbour’s design, they planned to observe three phases of a control group and a test group. Each phase would use t-tests to compare two unit tests for each group. They worked with teachers to implement time for playing PowerPoint games as well as a discussion on what makes games successful. The first implementation was a control phase that replicated past research and established a baseline. Once they finished that phase, they began to evaluate.

Evaluation and Reflection

Researchers can evaluate their designs both before and after use. The cyclical process involves careful, constant evaluation for each iteration so that improvements can be made. While tests and quizzes are a standard way of evaluating educational progress, interviews and observations also play a key role, as they allow for better understanding of how teachers and students might see the learning situation.

Reflection allows the researcher to make connections between actions and results. Researchers must take the time to analyze what changes allowed them to have success or failure so that theory and practice at large can be benefited. Collins (1990) states:

It is important to analyze the reasons for failure and to take steps to fix them. It is critical to document the nature of the failures and the attempted revisions, as well as the overall results of the experiment, because this information informs the path to success. (pg. 5)

As researchers reflect on each change they made, they find what is most useful to the field at large, whether it be a failure or a success.

After evaluating results of the first phase, Siko and Barbour revisited the literature of instructional games. Based on that research, they first tried extending the length of time students spent creating the games. They also discovered that the students struggled to design effective test questions, so the researchers tried working with teachers to spend more time explaining how to ask good questions. As they explored these options, researchers were able to see unit test scores improve.

Reflection on how the study was conducted allowed the researchers to properly place their experiences within the context of existing research. They recognized that while they found positive impacts as a result of their intervention, there were a number of limitations with the study. This is an important realization for the research and allows readers to not misinterpret the scope of the findings.

Conclusion

This chapter has provided a brief overview of the origin, paradigms, outcomes, and processes of Design-Based Research (DBR). We explained that (a) DBR originated because some researchers believed that traditional research methods failed to improve classroom practices, (b) DBR places researchers as agents of change and research subjects

as collaborators, (c) DBR produces both new designs and theories, and (d) DBR consists of an iterative process of design and evaluation to develop knowledge.

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Inferential Statistics

Phillip Isaac Pflieger

inference

Inferential Statistics

null hypothesis significance testing

Everyone makes inferences, general statements drawn from specific evidences or experiences, as they learn about and act in the world around them. Inferential statistics are powerful tools for making inference that rely on frequencies and probabilities. Consequently, an understanding of inferential statistics can improve one's ability to make decisions, form predictions, and conduct research. It can also protect one from the misused and misinterpreted statistics that are all too common occurrences.

This chapter is not meant to teach all statistical principles or to convince the skeptic of the value of quality statistical inference. Instead it is meant to provide a brief taste of inferential statistics, just enough to help the reader decide whether or not to pursue more information on the topic. Three general topics will be covered in the chapter: (1) the importance of a representative sample, (2) the types of questions that can be answered by statistics, and (3) the most common branch of statistical analysis, which is called Null Hypothesis Significance Testing (NHST).

Sampling

We make inferences when we do not have access to the whole picture. For example, a candy company may want to be certain of the quality of their candies, so they taste a few. It is ludicrous to expect the company to taste all of their candies, because they would no longer have anything to sell. However, when they say that a whole batch is good or bad based on a sample, they are wading into uncertain territory. The same is true in inferential statistics. The process of inferential statistics has been labeled, "decision making under uncertainty" (Panik, 2012, p. 2). To reduce uncertainty it is necessary for the sample to represent the population (the whole batch of candies in this case). If the sample is not representative, then the inferences drawn about the population would be incorrect.

Theoretically, the best way to get a representative sample is called simple random sampling (SRS). Simple random sampling means that every person in the population, or every candy in the batch, has an equal chance of being selected. In practice this is often difficult or impossible. Researchers cannot force people to participate in their studies, so they are automatically limited to those who are interested in the study in the first place. With many other limitations preventing a truly random sample, many other options become necessary. These quasi-experimental designs tend to be complicated, leading some researchers to gather whatever sample is convenient. However, convenience sampling is not a good practice, and it greatly increases the chance of a non-representative sample, which invalidates the generalizability of the research. Instead, the aspiring researcher should familiarize himself or herself with the more complex quasi-experimental designs.

Statistical Questions

Foundational to the design of the experiment or study is the selection of the research question. The selection of the question leads naturally into the selection of an analysis and therefore requirements on the data that can and should be gathered.

Many different types of analyses are available, and each one lends itself to a different type of question or set of questions. A regression, for example, will tell you how strong the relationship is between one variable of interest and another. It will also tell you if one variable predicts the other and helps you make predictive models. A simple t-test will tell how probable it is for one group to be different from another. While each test may answer different questions, it is important to consider that all statistical analyses share one limitation in particular. Inferential statistics can only answer questions of how many, how much, and how often.

This limit on the types of questions a researcher can ask comes, because inferential statistics rely on frequencies and probabilities to make inferences. Consequently, only certain types of data may be used: nominal, ordinal, interval, or ratio (Panik, 2012, p. 4).

Nominal data consists only of a classification into groups, such as male or female, or control group or experimental group. Ordinal data is also categorical in nature but includes an order placed on the data. For example, first and second place in a race tell us nothing about the relationship between the two runners other than the fact that the first place runner came before the second.

Interval data and ratio data are very similar to each other and are often grouped together under the terms numerical or quantitative data. Interval data are like temperature in degrees Celsius. They are numbers that have meaning, but the zero is not an absolute zero. In the case of degrees Celsius, a zero does not mean a complete lack of temperature. It just means the point where water freezes. The temperature scale of Kelvins is different. Zero on that scale means absolutely no heat, making this scale a ratio scale.

Ratio data is often, but not always, the ideal data for an analysis. However the best way to determine what type of data to gather goes back to the research question. The research question will not only help you decide if statistics will help you, but it will also help you decide what type of data you should gather.

Null Hypothesis Significance Testing

Most people who have read an academic article have been exposed to something called a p-value. The p-value is fundamental to the most common statistical practice today, Null Hypothesis Significance Testing (NHST). NHST involves estimating the probability that the average of your sample is different from some other expected value (the null hypothesis). This probability estimate is the p-value. For example, if a researcher was investigating whether or not two groups were different, the null hypothesis would be “the difference between group A and group B is zero.” If the difference between the groups was 3.7, and the p-value was .03, then there would be a 3% chance that the difference in our sample was 3.7 if the true difference was zero.

For the novice statistician this can seem like a bit of a black box. When examined fully, however, it is not too hard to understand. The whole process involves giving the null hypothesis a score based on how many standard deviations away from the sample mean it is. The p-value is calculated from this score, and if the p-value is below a preset value (usually .05), then we say that it is “significant.”

Airline Example

To better clarify the process associated with many statistical inferences, consider the data in Table 1 (R Core Team, 2016).

Table 1. Airline Passenger Data

1959	1960	Difference
360	417	57
342	391	49
406	419	13
396	461	65
420	472	52
472	535	63
548	622	74
559	606	47
463	508	45
407	461	54
362	390	28
405	432	27

This is the number of passengers that flew each month on a certain airline in 1959 and 1960, as well as the differences between the two. A researcher may want to know if there was a difference in passengers between the two years. This researcher would first need to clarify the null and alternative hypotheses and set the alpha level (the level our p-value has to be before we will believe the conclusions).

H_0 : The average of 1959 = the average of 1960. (i.e the difference = 0)

H_a : The average of 1959 \neq the average of 1960. (i.e the difference \neq 0)

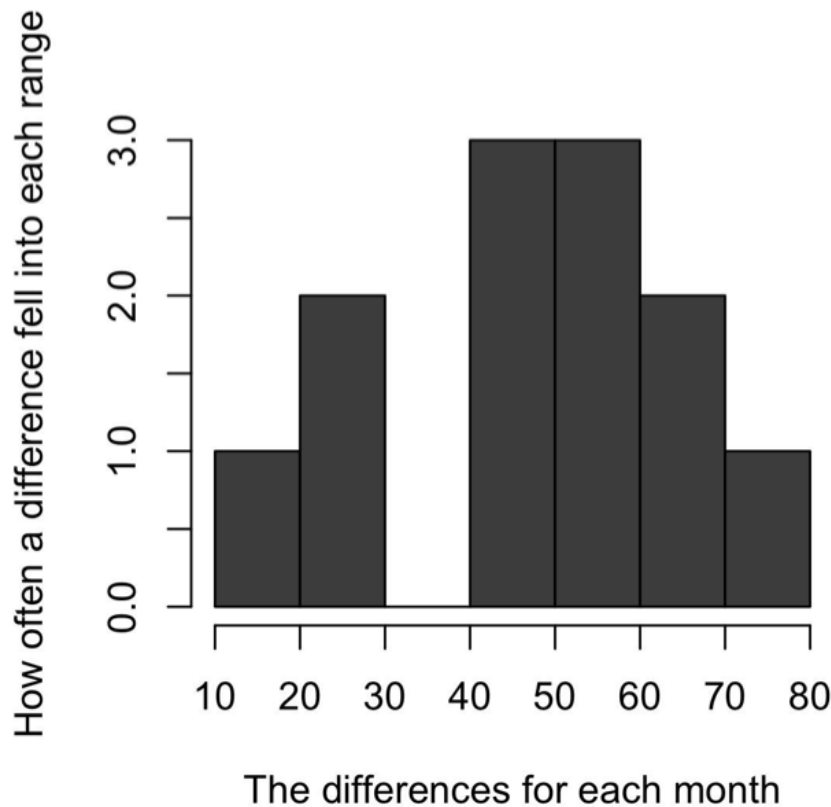
$\alpha = 0.05$

In other words, the researcher is assuming the two are the same but will have enough evidence to support that they are different if the p-value is less than 0.05.

The differences between the two groups is found in column three. Our first step is to find the mean of this column by adding all of the values and then dividing by the number of data points we added together. This gives us a mean of 47.83. This sample mean is a point estimate, or an approximation, of the true difference. We know this data follows a certain pattern (Figure 1), called a normal distribution.

Figure 1

Patterns of the Differences



Consequently, we know that 68% of the data is within one standard deviation, and 95% is within two standard deviations. A standard deviation is a measure of uncertainty. It is the average distance between the data points and the sample mean. We calculate the standard deviation using this formula (Moses, 1986, p. 50):

$$SD = \sqrt{\sum (x - \bar{x})^2 / (n - 1)}$$

The standard deviation for the airline data is 17.58. A test statistic is obtained using the following formula (Vaughan, 2013, p. 47):

$$t = \frac{\bar{x} - \mu}{\sqrt{s_x^2 / n}}$$

The test statistic for the airline question is 9.425. The p-value is the probability of getting a test-statistic as extreme or more extreme than the one you got, given the null hypothesis is true (Brase & Brase, 2016, p. 425). In other words, it is the probability of getting 47.83 as the average distance if the true average difference was 0. With a p-value of 0.000013, which is less than the .05 standard the researcher set at the start, there is enough evidence to reject the null hypothesis. Thus, the researcher concludes that there is a difference between the two groups. It is important to note that conclusions based on p-values alone lead to an incorrect answer 5% of the time. Consequently, it is good practice to interpret p-values in the context of other inferential statistics, such as effect sizes and confidence intervals. This approach is neither perfect, nor the only approach available, it is simply the most common.

Conclusion

Inferential statistics are an extension of the natural human tendency toward inference. They are powerful tools that can help answer questions such as how much, how many, or how often. An understanding of the process of statistics can help us be better consumers of research, prevent us from being misled by invalid or misinterpreted statistics, and give us another tool in the search for knowledge.

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Learning Analytics

Jesse Welsh

Education continues to quickly evolve and push beyond the borders of the traditional classroom. Recent survey research found that of the approximately 20 million higher education students in the US, 5.8 million are enrolled in at least one online or distance learning course (Allen et al., 2016). This figure represents a 263% increase over the last twelve years and shows little sign of slowing down (OLC, 2016).

While this growth has been accompanied by a number of positive outcomes for students like lower educational costs and increased accessibility to higher education, it has also given rise to a new method of educational evaluation: learning analytics. Learning analytics (or “LA”) takes advantage of the wealth and availability of learner data in online learning environments. Educational researchers analyze that data to produce or refine learning theory while educators can analyze the data to evaluate the efficacy of their instruction, make necessary improvements, and improve student outcomes.

The aim of this chapter will be to provide the reader with a meaningful definition of learning analytics, outline the benefits of its use, and recognize its limitations.

What is Learning Analytics?

The Society for Learning Analytics Research (“SOLAR”) defines learning analytics as “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (SOLAR, 2012, p.1). Similarly, researchers Romero-Zaldivar, Pardo, Burgos, and Delgado Kloos (2012) define learning analytics as the use of “data and any other additional observations that can be obtained... to directly impact the students, the instructors and the details of the learning process” (p. 1059). Or, more succinctly, learning analytics is the use and analysis of data to enhance learning. While the rise of digital learning environments has increased the quality and access to meaningful data, which drives learning analytics, it is important to note that LA can be and is adapted to in-person, classroom teaching. That said, much of this chapter will focus on learning analytics within online or blended-learning teaching environments.

Defining Features

There are two primary, defining features of learning analytics: (a) the leveraging of data management systems to effectively collect learner data in a timely fashion and (b) the utilization of analytic tools and techniques of other disciplines to interpret this data.

The first step of any data analysis is the effective collection of data. In the world of learning analytics, data is drawn from two primary sources: student information systems (SIS) and learning management systems (LMS). Student information systems provide information necessary for analysts to create learner profiles (age, grade, gender, etc). The learning management systems provide the information on learner behavior that can then be used for more thorough analyses (Siemens 2013).

As formal education has grown beyond the boundaries of a physical classroom in the digital age, learning management systems have become increasingly important in the new educational process. LMSs have been developed to fill the role of the traditional classroom. Where traditional, physical classrooms provide structure, location, and order to student learning, LMSs provide similar scaffolding to students in online or blended learning courses. LMSs are software that house lessons, assessments, and other pertinent information about a course. Because this content is located within a single program, data associated with how a learner interacts with the content is captured immediately and is accessible to educators and researchers. Compared to the data produced by traditional, in-class assessments and observations, the data captured by an LMS is diverse and rich in its content (Martin & Ndoye 2016). Where an in-classroom teacher may be only able to see the total number of problems a student completed on a math assignment or which problems he omitted, an LMS can capture all the same data and provide additional information, such as the time it took the student to complete the assignment, which questions took the longest, which specific types of questions the student struggled with the most, and more.

Once the data is collected from these systems, the second feature of LA emerges: the analysis of the data. The analysis of the learner data can take many different forms depending on the nature of the data itself. Qualitative data is organized and classified, while quantitative data is subjected to statistical analysis. This statistical analysis can take the form of descriptive statistics to help an educator understand what has happened or, in more complex cases, take the form of inferential statistics to make predictions about future performances and behaviors. In every case, learner data is examined, analyzed, and digested in such a way that meaningful trends and patterns emerge.

Learning Analytics v. Educational Data Mining

Running parallel to learning analytics is the sister discipline of educational data mining (or “EDM”). Both LA and EDM exist in the intersection of learning science and data analysis and see the analysis of learner data as the means to improve education (Papamitsiou & Economides, 2014). Because of this shared goal, much of the academic literature groups the two fields together and the two communities often collaborate and share ideas with each other at educational conferences.

Despite these similarities, there are important differences between LA and EDM that should be understood. Siemens and Baker (2012) found five key areas of difference between the two. Among these differences are: (1) a preference for automated paradigms of data analysis (EDM) versus making human judgment central (LA); (2) a reductionist focus (EDM) versus a holistic focus (LA), and (3) a comparatively greater focus on automated adaptation (EDM) versus supporting human intervention (LA) (Siemens & Baker, 2012).

Benefits

By leveraging the vast amounts of data available, learning analytics offers several meaningful benefits to learners, teachers, and researchers. While much can be said about how an analysis of learner data can enhance and improve extant theories of education, the focus of this chapter will only be on the benefits that LA provides to learners and their teachers.

Support for the Learner

Students can receive more meaningful and timely feedback through the use of learning analytics. A teacher’s feedback is motivated by the needs they see in their learners. Traditionally, those needs are only perceived by what a teacher observes within their classroom or, at best, what might be reflected in homework assignments that are turned in. This constraint not only limits the amount of data upon which a teacher can act, but it also introduces a delay between the time when help is needed and when a teacher is finally able to perceive that need and intervene. Consider the example of a struggling math student. While the student struggles in his own home with a homework assignment, specifically with understanding how to use the slope-intercept form of a line to graph the line, his struggles go unseen by his teacher. In class the next day, the student is unable to get his questions answered because other students had questions of their own that diverted the attention of the teacher. As additional assignments stack up, the problem

compounds itself, and the need for help gets pushed aside by the student. When the time comes for the student to turn in all his homework at the end of the unit, only then will his teacher be able to see the need for help. At that point, whatever help and feedback can be provided will likely be too late. In comparison, LA embedded within an LMS could immediately recognize and diagnose the student's struggle and provide an immediate intervention, in this case steering him to a YouTube video providing additional explanation on how to use the slope-intercept version of a line when graphing. The promise of this timely feedback empowers learners to be self-directed and confident in their own learning process. "The availability of such personalised, dynamic, and timely feedback shall support the learner's self-regulated learning as well as increase their motivation and success" (Iftentahler et al, 2014, p. 123).

Not only can feedback be personalized and enhanced, even the content of a lesson can be modified to meet individual needs by using LA:

Learning content provided to learners can be personalized—a real-time rendering of learning resources and social suggestions based on the profile of a learner, including conceptual understanding of a subject and previous experience. For example, an integrated learning system could track a learner's physical and online interactions, analyze skills and competencies, and then compare learner knowledge with the mapping of knowledge in a discipline. Based on evaluation of a learner's knowledge, an LMS or learning system could provide personalized content and learning activities. (Siemens, 2013, p. 1390)

While a teacher using traditional methods of evaluating his teaching may struggle to adapt and modify the content of his teaching to meet the needs of his individual students, by using LA, a teacher can create dynamic content that is custom tailored to each of his students.

Support for the Instructor

Learning analytics provides another benefit to the designers of instruction: improved feedback on the efficacy of their learning systems to drive improved designs:

Through the use of analytics, educational institutions can restructure learning design processes. "When learning designers have access to information about learner success following a tutorial or the impact of explanatory text on student performance during assessment, they can incorporate that feedback into future design of learning content" (Siemens, 2013, p. 1390).

Limitations and Criticisms

Learning analytics is not without its limitations and criticisms. The three primary limitations and criticisms of LA are: (1) data quality concerns, (2) ethical concerns about the ownership and appropriateness of the collection of large amounts of learner data, and (3) the fear of an automated educational system and its effect on student learning.

As has been made clear, LA is heavily reliant on data. To wit, it is essential for any teacher or researcher using LA to collect good, high quality data. High quality data is both accurate and complete. Learning management systems provide teachers access to more data than was ever previously available, but there is danger in accepting all the data as accurate. For example, if a teacher notices that one of her students spent double the amount of time on a particular homework assignment compared to his previous assignments, the teacher may conclude the student is struggling with the material and be inclined to intervene and assist the student. A more fully-developed course and more sophisticated LMS may even automatically provide remediation and help to the student. However, the reality of the situation may be as simple as the student left his computer for an hour to go eat dinner with his family.

While the advent of the LMS provides a single warehouse to collect and store significant amounts of data, LMSs do not capture all the important data associated with how a student thinks about, wrestles with, and interacts with the content of his class. Teachers may use additional software outside of the LMS to meet certain instructional objectives; students may take time to discuss a lesson or a difficult problem with a parent; and off-line discussions may occur between

peers via text. All these important interactions would not be found or expressed in the data captured by an LMS. As Siemens (2013) expressed, “the data trails that learners generate are captured in different systems and databases. The experiences of learners interacting with content, each other, and software systems are not available as a coherent whole for analysis” (p. 1393). This presents a two-fold problem: (a) finding effective methods to capture a totality of learner interactions and (b) the collection and unification of all the data for appropriate analysis. Both lead to the same result: incompleteness of data.

There are also ethical questions associated with LA. While most would agree that providing teachers and researchers with more data on learners to improve outcomes is a good thing, many have begun to ask questions about the appropriateness of the data collection involved. “Yet collection of data and their use face a number of ethical challenges, including location and interpretation of data; informed consent, privacy, and deidentification of data; and classification and management of data” (Slade & Prinsloo, 2013, p.1510). To illustrate the root of this concern, consider the previous example of a math student working through a homework assignment. Traditionally, a student works through the homework assignment at home and shows up the following day with the completed work. The teacher does not know how difficult the assignment was for the student, how he came to his answers, how long it took him to complete, or what specific types of questions he had as he worked through the different questions. A teacher could gain “access” to that data by voyeuristically watching the student through the window of his home as he completed the work. While such a notion seems outlandish, many critics of LA believe that the ever-watchful eye of an LMS capturing and analyzing large amounts of data about a student works in a similar fashion.

The last major concern associated with LA is the fear of the consequences of moving toward a more automated system of education. Learning analytics provides teachers not only with the ability to see and assess learner needs in a timely fashion, but the potential to see those needs forecasted before they even come to fruition. The data, coupled with predictive tools, can see potential issues before they fully form. With such power, teachers can quickly intervene with students. But at what cost? What might be lost in minimizing the struggle of students? Researchers Ifenthaler et al (2014) posited that “such automated systems may also hinder the development of competencies such as critical thinking, metacognition, reflection, and autonomous learning, especially when too few, too much, or the wrong kind of feedback is provided” (p.124).

Conclusion

The rise of online education and the overall digitization of education have driven an explosion in both the quantity and quality of available data about learning. With the proper application of appropriate analysis techniques to these stores of data, researchers can drive forward our understanding of learning while educators can better understand and meet the needs of their students. As educational technology like LMSs continue to evolve and collect more and better data, and the analytical tools continue to mature, the promises of LA draw ever closer to their full realization.

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Psychometrics

Susanna Fullmer & David Daniel

Psychometrics

Item Response Theory

Measurement

Reliability

Validity

Generalizability Theory

Measurement is the process of assigning numbers to attributes. As a society, we take measurements of almost everything—weight, height, temperature, the speed our car is going, the amount of time using our phones, and the amount of money in our bank accounts are a few examples. For tangible, physical attributes, measurement is easy and straightforward—a number is arrived at. But have you ever considered how we have come to measure happiness, intelligence, or confidence? These traits are what psychometricians call latent variables, or variables that cannot be physically or directly measured. The ability to measure these variables accurately and reliably is the focus of the field of psychometrics. As the field of psychometrics developed, tools like Item Response Theory (IRT) and Classical Test Theory (CTT) have increased our ability to measure latent variables.

History and Development of Psychometrics

Understanding the history of psychometrics helps us appreciate some of the difficulties in measuring these latent variables. The roots of psychometrics can be traced back to the late 1700s, but most modern psychometric methods were developed in the ensuing 100 years. The field of psychometrics largely developed from the fields of psychology and statistics. Eventually, psychometric principles were applied to education. We will explore a few of the major contributors and their contributions to modern-day psychometrics.

Francis Galton is considered the father (sometimes grandfather) of behavioral science (Clausen, 2007). In the late 1800s, Galton was one of the first people to begin measuring and investigating differences in human traits (Jones & Thissen, 2007). He primarily focused on measuring physical traits and took measurements of thousands of individuals' characteristics. Eventually, he attempted to measure latent variables, which he viewed as mental traits. However, his major contributions include bringing statistical analysis to behavioral science. He was the first to use methods such as correlation (how related two variables are) and apply the normal distribution (a common, bell-shaped, symmetrical distribution, which a number of variables follow naturally) to understand the characteristics he measured and their relationships.

In the early 1900s, there was a shift to specifically testing intelligence. Two scientists, Alfred Binet and Theophile Simon began testing cognitive abilities. Their goal was to assign someone a "mental age" based on the results of a test (Jones & Thissen, 2007). Inspired by their work, Charles Spearman wrote the paper "General Intelligence', Objectively Determined and Measured", which some view as the beginning of modern-day psychometrics. Spearman (1904) took Binet and Simon's research a step further by analyzing cognitive tests and assigning a general intelligence factor, which he designated as "g". Within a few years, Lewis Terman also took Binet and Simon's work and developed what we know today as the intelligence quotient score (IQ; Jones & Thissen, 2007).

Around the 1920s, psychometrics began to look like what we know today. This shift happened largely as Louis Thurstone began applying psychometrics to education. He wrote tests like the Psychological Examination for High School Graduates and College Freshmen. This test assigned two scores, one for linguistic skills and another for quantitative skills. He wrote other tests for many years, allowing him opportunities to develop different methods used today in the field of psychometrics. These methods include multiple factor analysis and test theory. He also brought to light the ideas of reliability and validity, emphasizing their importance in psychometric testing (Jones & Thissen, 2007). Although it took time, these methods and theories are the tools that psychometricians use today.

The “How” of Psychometrics

Currently, the two renowned tools of psychometrics are generalized to classical test theory (CTT) and item response theory (IRT). However, the field is more nuanced than that. Other methods are intertwined with CTT and IRT, such as generalizability theory and factor analysis, which we will explore here. However, understanding CTT and IRT first requires an understanding of psychometric fundamentals: building a model, reliability, and validity.

Building a Model

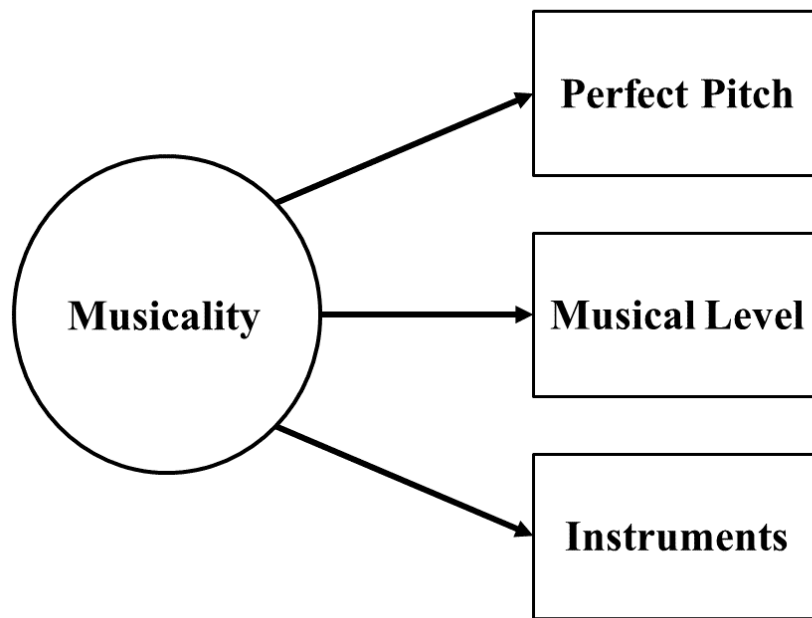
As previously mentioned, psychometrics studies the measurement of latent traits. Measuring the physically immeasurable can be done by assessing multiple related variables, called indicator variables, that can be objectively measured. Depending on the field of study, the composite of indicator variables is referred to as an instrument, model, scale, test, assessment, or questionnaire. Hence, we will use these terms interchangeably. To illustrate creating an instrument, we refer to a fictional instrument for measuring musicality that uses the following indicator variables:

1. Do you have perfect pitch? (yes/no)
2. Which word best classifies your musical level? (amateur, casual, experienced, professional)
3. How many instruments do you play?

We could diagram our model as shown in Figure 1. In the basic format for drawing models, referred to as path diagrams, latent traits are always represented by circles, and indicator variables are represented in box shapes (Wang & Wang, 2012). Note that the arrows point from the latent trait to the indicator variables. The theory is that the latent trait is what determines how subjects respond to the indicator variables.

Figure 1

Path Diagram of a Fictional Musicality Instrument



Reliability and Validity

Reliability is a specific term in test theory that means the results are consistent. A respondent taking a reliable test multiple times would result in scores that are similar. Reliability can refer to different aspects, such as “consistency over a period of time, over different forms of the assessment, within the assessment itself, and over different raters” (Miller et al., 2013, p. 110). In this chapter, we focus on the internal consistency aspect, in which case, reliability is measured using correlation. Correlation is the assignment of a value, called the correlation coefficient, that measures the relationship between two variables.

The ideal calculation for reliability requires correlating two scores from the same respondent under the exact same conditions, including time. Since replicating conditions is implausible, we use estimations instead (Miller et al., 2013). For instance, a commonly-used estimation is Cronbach's alpha coefficient, which comes from splitting the test in half, resulting in two tests taken under the same conditions. The scores of one half are then correlated with the scores of the other half. That process is then repeated for all possible test-half combinations, and the average of all those correlation coefficients is the Cronbach's alpha coefficient (Wu et al., 2016).

While reliability is vital, it is not sufficient without validity. Validity assesses how adequately the test measures the intended latent trait. Imagine throwing darts. It is not enough for darts to land within centimeters of each other if the darts land far from the target. In psychometrics, darts landing close to each other are akin to reliability, while landing on the target represents validity; both are needed to succeed. Like reliability, validity exists on a spectrum of high and low. Unlike reliability, validity is determined more by evaluative judgments rather than calculated values. According to Miller et al. (2013), validity is evaluated based on the consideration of content, construct, criterion, and consequences.

- Tests include only a sample of all possible indicator variables. Content validity measures the representativeness of that sample. In the musicality instrument from Figure 1, removing the first two questions would decrease content validity. Asking about perfect pitch, musical level, and instruments provides a fuller picture of musicality than just instruments alone.
- Construct validity refers to the relevance of the indicators to the latent trait. For instance, a psychological questionnaire measuring depression probably does not need a question about ice cream preference. Likewise, a math test with word problems can unintentionally measure English prowess. Indicator variables should be well thought out to ensure high construct validity.
- Criterion validity requires comparing test results to a standard. A school teacher might calculate the correlation between their students' test results and the national average. The higher the correlation with a trusted source, the higher the criterion validity.
- The last consideration is consequence validity, which is a subjective judgment on whether the test's consequences are overall beneficial or harmful. For example, a high stakes standardized test might lead to student burn out but appropriately measure students' compatibility with prospective colleges. In this case, consequence validity would be the judgment made of whether the benefits of compatibility outweigh the disadvantages of burn out.

Test Theory

A common misconception among researchers is that IRT and CTT are interchangeable, when they actually "provide complementary results" (Wu et al., 2016, p. 74). While CTT focuses on the reliability of the results, IRT focuses on the relationship between the items and the latent trait. With the knowledge of the fundamentals, these differences can be explored in some depth.

Classical Test Theory

The foundation of CTT is that the observed score from the instrument, that measures the latent trait, is made up of a respondent's true score and random errors. Written as an equation, that is:

$$X = T + E$$

where X is the observed score, T is the true score, and E represents random error. Random error refers to controllable errors and errors due to chance. Since the true score will always be unknown, instruments can only estimate true scores, and the accuracy of the estimates can be evaluated using reliability measures.

Wu et al. (2016) showed mathematically that measuring reliability estimates the correlation of observed scores and true scores. Ideally, reliability should have a high, positive correlation meaning that as an observed score increases, the true score also increases.

Generalizability Theory

Reliability and validity are central components to CTT. However, generalizability theory, referred to as the daughter of CTT, offers an improved conceptualization of reliability and validity. Consequently, more modern approaches are shifting to the generalizability theory (Prion et al., 2016). Generalizability theory expands on Equation 1 by adapting how the errors are used. While CTT lumps all errors together, generalizability theory isolates each error transforming the equation to be more like the following (Prion et al., 2016):

$$X = T + E_1 + E_2 + E_3$$

For example, E1 could represent spelling errors, E2 could represent biased grading, while E3 could represent respondents misreading answer choices. In Equation 2, only three errors are listed for simplicity but there can be any number of errors.

Item Response Theory and Factor Analysis

Recall that instruments are made up of indicator variables. Because the relevance and priority of indicator variables can be subjective, IRT and factor analysis are used to quantify each indicator's contribution. These methods of analysis are closely related to each other. In fact, some researchers consider IRT a subcategory of factor analysis while others see them as two separate forms of analysis that merely intersect like a Venn diagram. Focusing on the Venn diagram analogy, the two methods intersect in their purpose, but what falls outside the intersection (i.e., their differences) is in their calculations and data restrictions (Jones & Thissen, 2007; Groenen & van der Ark, 2006).

The complexity of the calculations is beyond the scope of this chapter; however, an overview is that IRT calculations are based on probabilities, whereas factor analysis calculations are based on covariance, or a measurement of how much the items are related to each other (Jones & Thissen, 2007; Wang & Wang, 2012). Factor analysis and IRT also differ in the type of data that can be used. Notice that the questions in the musicality model have different answer options.

1. The first question has "yes" or "no" answer options, which produces dichotomous data.
2. The second question gives limited categories, which produces categorical data, also referred to as nominal or polytomous data. When the order of categories matters (e.g., categories of "low", "medium", and "high"), the data is ordinal.
3. The third question is not limited by categories. Instead, the possible values are endless, which produces continuous data.

While IRT is limited to models with dichotomous and categorical data, factor analysis can use all three types of data mentioned. However, the verdict is still out on which method produces more accurate estimations. Maydeu-Olivares et al. (2011) noted that the accuracy of estimations is indistinguishable between IRT and factor analysis when using dichotomous data. However, by most standards, IRT is more accurate than factor analysis with ordinal data.

Conclusion

The measurement of physical characteristics is, for the most part, straightforward. The difficulty comes in measuring latent variables. Many psychologists and statisticians attempted to measure these variables leading to the formation of the field of psychometrics. In the field of psychometrics, factor analysis and IRT are two tools that have been developed to help determine which indicator variables influence the latent variables. In addition, classical test theory and generalizability theory help to confirm the reliability of a test. These basic concepts help build the foundation for the field of psychometrics, but the field has much more depth and nuance, which we invite you to explore on your own.

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[Susanna Fullmer](#)

Brigham Young University



[David Daniel](#)

Brigham Young University

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Continuous Improvement Dashboards

Bill Kemsley

Learning is a product of interaction. (Elias, 2011, p. 1)

Each semester, a student's interactions with peers, teachers, and content leads to learning (see Moore, 1989). As formal education increasingly takes place online, these interactions take on new forms. Students might have conversations with fellow students and their teachers asynchronously through discussion boards and synchronously through video conferencing software, or they might read textbooks, watch educational videos, complete projects, and take quizzes and tests. As students interact in online environments, they leave digital breadcrumbs of their learning experience that help reveal their learning paths, norms, and behaviors. However, understanding what these bits of data mean can be difficult and has necessitated the emergence of the new field of Learning Analytics, which focuses on "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (SOLAR, 2012, p.1).

When learning analytics data is visualized and reported, people can understand and implement changes in response to the data to improve learning. A common tool to report data about learners and their learning environment is a learning analytics dashboard (LAD). For instance, learning analytics dashboards are increasingly becoming incorporated into Learning Management Systems (LMS; Park & Jo, 2015, p. 110), wherein a student logging into an LMS may have access to a student-facing dashboard that provides feedback from the teacher on assignments and provides recommendations of content areas to study further. Conversely, a teacher logged into an LMS for the same course may have access to a teacher-facing dashboard that identifies struggling students and suggests ways to intervene.

Student- and teacher-facing LADs fulfill a variety of purposes. Student-facing LADs report information about students' online learning experiences, provide feedback, encourage self-reflection and self-awareness, and motivate learners to achieve performance outcomes (Roberts, Howell, & Seaman, 2017, p. 318). To accomplish these purposes, student-facing LADs include features such as links to additional readings, information about course difficulty, progress within a course, other students' time management practices, and personalized feedback on performance in relation to peers and learning outcomes (Roberts et al., 2017, p. 318).

Teacher-facing LADs, on the other hand, are frequently used to identify struggling students. In addition, they may also be used to help teachers better understand their courses, reflect on teaching strategies, and identify ways to improve course design (Viberg, 2019, p. 2), although these purposes are less prevalent than that of identifying at-risk students. Teacher-facing LADs with early warning systems for at-risk students may use complex predictive modeling and can include data sources such as students' previous academic histories, current grades, time spent in different sections of the LMS, and clickstream data about learning activities (Viberg, 2019, pp. 1-2).

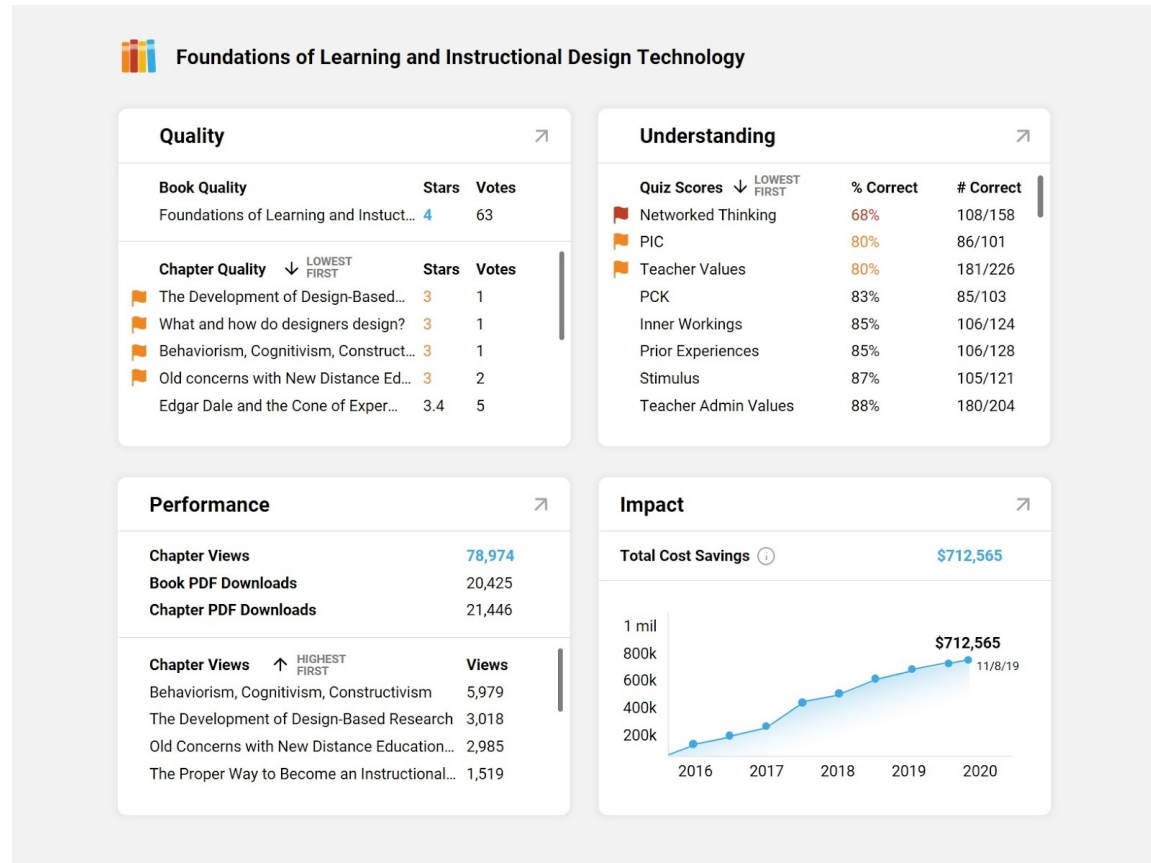
Continuous Improvement Learning Analytics Dashboards

While student- and teacher-facing LADs remain the most common types of LADs, dashboards have also been created to facilitate the continuous improvement of online learning resources. This emerging type of LAD, known as a continuous improvement LAD, provides feedback to educational content creators about the quality and performance of educational

content (see Figure 1). Continuous improvement LADs are relatively new, but they have been incorporated into online educational platforms such as textbook publishing platforms (e.g., EdTech Books), university library websites (Loftus, 2012), and government websites focused on educating the public (Desrosiers, 2018).

Figure 1

Example of a Continuous Improvement Learning Analytics Dashboard



When designing a learning analytics dashboard, designers must consider who the dashboard is trying to influence and what assumptions it is making about deficits contributing to poor performance. While a complete analysis of the underlying value systems of each type of LAD is beyond the scope of this chapter, Table 1 may be helpful in understanding intended audiences and designer beliefs about deficits that influence the design of each type of LAD. Stated simply, this means that the intended audience and design of each type of dashboard implies that the problem is located in a particular place. This deficit might be ascribed to the student (e.g., poor study habits), the teacher (e.g., poor pedagogy), or the content (e.g., poor design).

Table 1

Targets of Underlying Deficit Mindsets that Influence Different Types of LADs

Target of Deficit Mindset	How to Improve Student Performance	Types of LADs Influenced by Value System
Student	Encourage student effort Modify student behavior	Student-facing LAD Teacher-facing LAD
Teacher	Improve teaching strategies Intervene with at-risk students	Teacher-facing LAD

Target of Deficit Mindset	How to Improve Student Performance	Types of LADs Influenced by Value System
Content	Improve content	Teacher-facing LAD Continuous improvement LAD

Note that each type of deficit mindset lends itself to specific actions that dashboard users can take to improve the learning experience. For example, students can study more and better manage their time; teachers can improve their teaching strategies, motivate and inspire their students, and adjust the resources they use; and content creators can improve the quality of their content. Rather than attributing poor performance to external factors, such as how students are using content or which teaching strategies are employed, a continuous improvement LAD attributes poor performance to poor content quality and uses metrics that help content creators improve their content. When designing a continuous improvement LAD, then, dashboard designers should ensure that the information displayed on the dashboard is relevant to and actionable by content creators and that it also provides ongoing information about how content changes are impacting student performance.

As a recent example of a continuous improvement LAD, in 2018, the Massachusetts Digital Services team developed a dashboard that helped “Mass.gov content authors make data-driven decisions to improve their content” (Desrosiers, 2018). The dashboard took data from a variety of sources, including Google Analytics, Siteimprove, and Superset, and integrated the data into the website’s content management system (CMS). As a result, content authors could simply select an Analytics tab when editing their content to view performance metrics and access recommendations to improve their content. The team also collected ongoing online survey data to obtain direct feedback from Mass.gov users about their satisfaction with the site, reasons for using the site, and suggestions to improve the site.

After eight months of analyzing potential performance indicators and validating indicators with five partner agencies using a sample set of the website’s 100 most-visited pages, the dashboard developers summarized performance indicators into four categories: (1) findability, (2) outcomes, (3) content quality, and (4) user satisfaction (Desrosiers, 2018). Each category received a score from 0-4, which was then averaged to create an overall score. In addition, the dashboard included general recommendations for ways content creators could improve content in each of the four categories.

The dashboard was valuable to content creators, because it showed how specific content pages were performing over time and provided specific suggestions on how to improve content. For example, if a content creator saw that a page about SNAP benefits had a Content Quality score of 2, the content creator could find and implement recommendations from the dashboard, such as “Use Siteimprove to check for broken links and fix them” and “Spell out acronyms the first time you use them” (Desrosiers, 2018).

As this example illustrates, designing an effective continuous improvement LAD can be a complex task that requires a deep understanding of both the dashboard users (in this case, the creators of the Mass.gov content pages) and the people accessing the content (in this case, the visitors to Mass.gov). Just as a continuous improvement LAD facilitates iterative improvements to an educational website or platform’s content, this example suggests that an iterative process can be used in designing and developing the dashboard itself, wherein user feedback can be used to improve the usability and efficacy of the dashboard.

Best Practices in Designing a Continuous Improvement LAD

The data analyzed and visualizations displayed on a continuous improvement LAD for a government website would likely be very different from those on a different site, such as an online textbook publishing platform, “because pedagogical, technical and organisational aspects of learning are complex, [and] they must be carefully interpreted within the used context” (Viberg, 2019, p. 1). Yet, despite differences from one continuous improvement LAD to another, effective continuous improvement LADs may share several characteristics.

In 2004, as analytics dashboards were emerging in business and other fields, data visualization consultant and author Stephen Few defined a dashboard as “a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance” (p. 3). Fifteen years later, dashboards have become a widely used data analytics tool, and several recommendations have been suggested for designing effective dashboards. Many of these recommendations fall within four categories: (1) design for the dashboard’s intended purpose; (2) choose relevant metrics; (3) ensure data is current and accurate; and (4) use effective visual displays. I will now describe each of these recommendations in detail.

Design for the Dashboard’s Intended Purpose

First, the purpose of a dashboard should direct the dashboard’s design. As explained previously, continuous improvement LADs facilitate the continuous improvement of online content and are informed by a content-deficit mindset. In addition, the design of continuous improvement LADs is influenced by the needs of the content creators using the dashboards and by the type of educational content assessed by the dashboards.

Designers of continuous improvement LADs may benefit from frequent communication and collaboration with content creators (De Laet, 2018). Through interviews and surveys, dashboard designers can better understand the information content creators need to know about the students using the learning content so they can change the content to better meet the students’ needs. For example, authors publishing textbooks on an online textbook publishing platform may desire to know which textbook chapters are most relevant to students and which topics students have a hard time understanding. These questions may help dashboard designers choose appropriate metrics for the dashboard that pertain to this information. Dashboard designers can show iterations of the dashboard design to content creators and use their feedback to inform subsequent iterations of the dashboard’s design.

Choose Relevant Metrics

Second, metrics are the building blocks of any dashboard and of the visualizations displayed on that dashboard. Metrics are “measures of quantitative assessment used for assessing, comparing, and tracking performance” and comparing current performance with historical data or objectives (Young, 2019). Metrics should emanate consciously and directly from the intended purpose of the dashboard. In the case of continuous improvement LADs, metrics should be selected that measure and provide actionable data for content creators to evaluate student learning and improve content.

In business analytics, the term key performance indicators (KPIs) is used to identify meaningful metrics. The implication that metrics should measure only important, or key, indicators and that the measurement is one of performance applies neatly to continuous improvement LADs. Are students able to successfully demonstrate learning through knowledge assessments and other exercises? How often is a particular learning product (e.g., a textbook or educational video) accessed or completed? How do students rate the quality of the resource? Put simply, continuous improvement LADs should report key metrics to content creators to help them improve their content.

Ensure Data Are Current and Accurate

Third, regardless of which metrics are selected, a dashboard is only useful if it is based on current, accurate information. Dashboards should be connected to accurate data sources and should be updated regularly so that content creators can make informed decisions on how to improve their content. While some types of dashboards, such as strategic business dashboards, may only need data to be updated monthly, quarterly, or even annually, other types of dashboards, such as operational business dashboards, may require real-time data updates (Few, 2013). Designers of continuous improvement LADs should consider both the purpose of the dashboard and the needs of dashboard users when determining which data sources to use and how frequently the data should be updated.

Continuous improvement LADs often require data integration, which is defined as “the process of collecting data from disparate locations and systems, and presenting [the data] in a meaningful and useful way” (Boonie, 2016, p. 1). For example, as mentioned previously, the Mass.gov dashboard combined data from Google Analytics, Siteimprove,

Superset, and other sources. Dashboard designers should ensure that data from disparate databases has been properly transformed and normalized before being integrated into a continuous improvement LAD (Boonie, 2016).

Use Effective Visual Displays

And fourth, after selecting appropriate metrics and integrating relevant data sources, dashboard designers must decide how to effectively display data. A variety of books and research articles have been written about dashboard design and data visualization (see Knafllic, 2015; Few, 2012; & Few, 2013); in this section, I will describe a few outstanding principles.

To begin, continuous improvement LADs should display high-level summaries that can be viewed and interpreted at a glance. Because humans have limited working memory, they are not able to store large amounts of visual information at a time (Yoo, Lee, Jo, & Park, 2015). As a result, dashboards are less effective if users must scroll through large amounts of content or select various tabs to identify and piece together information. Instead of having excessive visualizations, dashboards should prioritize information and display on a single screen the information that is most important. In accordance with psychologist George A. Miller's observation (1956) that the average person can hold 7, plus or minus 2 objects in working memory, some dashboard designers recommend that no more than 5 to 9 visualizations be displayed on a dashboard's primary view. Interactions such as buttons, tabs, tooltips, and scrolling can be used to display additional content without overwhelming the user; however, the dashboard should not rely on these interactions to report key information (Bakusevych, 2018).

As Stephen Few explained (2004), a defining characteristic of a dashboard is "concise, clear, and intuitive display mechanisms" (p. 3). Dashboards should not use ostentatious or distracting visuals; rather, dashboards should apply minimalistic design principles that draw attention to important data. For example, dashboards should appropriately use negative space (sometimes called white space) so that the information is not too crowded and relevant data stand out to users (Bakusevych, 2018).

Dashboard designers should select the appropriate visuals to display different types of information. For example, bar charts are useful in comparing values at a point in time (e.g., current quality rating of an educational video) whereas line charts are useful in comparing values over time (e.g., total student savings as a result of using an open educational resource textbook). While a large variety of graph types may be used to report data, Tables 2 and 3 about common graph types may prove useful in deciding which visuals to display for different types of data (see Bakusevych, 2018 & Knafllic, 2015, pp. 35-69).

Table 2

Purposes of Common Graphs Representing Data at a Point in Time

Analyze relationships	Compare values	Analyze composition	Analyze distribution
Scatterplots	Bar/column charts	Tree map	Scatterplots
Bubble charts	Circular areas charts	Heat map	Histograms
Network diagrams		Pie/donut chart	Bell curves

Table 3

Purposes of Common Graphs Representing Data Over Time

Analyze relationships	Compare values	Analyze composition	Analyze distribution
N/A	Line graphs	Stacked column chart	N/A
	Slope graphs	Stacked area chart	
		Waterfall chart	

As Tables 2 and 3 indicate, graphs may be used to analyze relationships, composition, and distribution, as well as to compare values. Whether the data depict a specific point in time or illustrate changes over a period of time influences which type of graph should be used.

Dashboards directed toward users whose native language reads from left to right should display the most important information in the upper left and then organize the rest of the information in a Z-pattern. In other words, dashboard designers should design with the assumption that users will view the first row of visualizations from left to right and then move down to the next row following the same patterns. Graphs with related information should be close to each other so users do not have to look back and forth between distant areas of the dashboard.

In addition to following these general recommendations, dashboard designers should use effective visual displays to address a challenge unique to continuous improvement LADs; namely, the data used to inform actions is iterative. When content creators make adjustments to content based on feedback from the dashboard, the data about that content is no longer valid for making further judgments. For example, a continuous improvement LAD on an online textbook publishing platform may display the scores of knowledge check questions. If a content creator observes that a specific question has low scores, the content creator may clarify parts of the chapter or adjust the wording of the knowledge check question. In either case, after the adjustments are made, the data about the knowledge check scores are no longer valid.

As this example illustrates, each iteration, improvement, or adjustment made to content invalidates previous data about that content. How can effective visual design address this problem? To compensate for the problem of invalid data, continuous improvement LADs must clearly document iterative changes to content. In the case of the adjusted knowledge check question, the dashboard must visually show content creators how scores to the knowledge check question changed in relation to the adjustments made. By clearly displaying when content changes occurred, content creators can see to what extent their changes led to desired outcomes, and can know when additional changes are needed.

Conclusion

As students enroll in online classes and engage with digital content, they leave behind an abundance of data that, if properly collected, reported, and analyzed, can lead to enhanced learning. Learning analytics dashboards are an effective tool to visualize and report these data so students, teachers, and content creators can make informed decisions about their role in the learning process. An emerging type of LAD, known as a continuous improvement LAD, helps content creators make incremental improvements to their content using data about student performance with the content and user feedback. While the metrics and visualizations of continuous improvement LADs vary depending on the type of content the dashboard seeks to improve, several data visualization and dashboard best practices may help in designing an effective continuous improvement LAD. These practices include designing for the dashboard's intended purpose, selecting relevant metrics, maintaining accurate and up-to-date data, and using effective visual displays. As more educational platforms begin to collect and report data about the quality and performance of their content, content creators using these platforms will be able to make informed, data-driven decisions about how to improve their content and increase student learning.

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Copyright

Elizabeth Robinson

Education

Copyright

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Copyright Law

Copyright is a legal protection for creative works allotting a specific period of time, which varies based on the country and type of work produced, in which only the creator can profit from the use, sale, or distribution of a creative work. During this protected period, the creator of a work can license their work to others, either for a fee or for free, but they continue to control primary distribution rights to their work.

By examining the history of copyright, and various legal cases where copyright has influenced the field of education, this chapter provides a background context for understanding the basis of copyright and potentially how to avoid copyright violations. In addition, the principle of fair use, which is commonly used and relied upon in education, is briefly examined.

History

The US copyright law is included in the Constitution and was originally intended to promote new scientific inventions. Copyright claims were handled at a local level until 1870 when the US copyright office was centralized under the Library of Congress. This centralization process required submission of two copies of each book, pamphlet, map, print, and piece of music registered.

The terms of copyright were originally set in 1790 as 14 years, with an option to submit an application for a renewal that would cover a second 14 years. The length of time copyright was in effect was first changed in 1831 to last for 28 years with an option of a 14 year renewal, and then again in 1909 to change the renewal period to a second 28 years. In 1978, the length of protection was changed to protect works for the life of the author and fifty years after death.

1980 was the first time that computer programs were eligible for copyright protections, and their inclusion was updated in 1990 with provisions allowing for renting and lending of programs. 1992 saw the passage of the Digital Audio Home Recording Act which created rules for distribution of audio recordings and set standards for royalty payments. This was followed in 1997 by the No Electronic Theft Act which set penalties for illegally distributing recordings by electronic means.

In 1998 the Sonny Bono Copyright Term Extension Act set the length of copyright to be the life of the author plus 70 years after death; and that same year also saw the passage of the Digital Millennium Copyright Act which gives internet service providers limited immunity for being prosecuted for copyright infringement.

2002 also saw a major update to the law with the Technology, Education, and Copyright Harmonization (TEACH) Act which allowed for certain accredited nonprofit groups to distribute copyrighted materials for digital education purposes.

Important Legal Cases

While there are a large number of legal cases regarding copyright law, presented are five cases that might be of interest to any student of education and technology. This list is by no means comprehensive but instead attempts to highlight specific cases which may be relevant in an educational context.

Williams and Wilkins Co. vs. The United States

In this case, publishers of specialized medical journals sued the National Institute of Health for distributing photocopies of their published articles to medical researchers. The U.S. Court of Claims ruled in favor of the NIH saying that the benefit to medical science, and injury to the field if photocopying was illegal, outweighed the counter claim by the publishers.

This case was taken into consideration of the 1976 changes to US copyright law which set policies about making and distributing copies of a copyrighted work. Distribution of copies, both physical and digital, has remained a contentious issue since this ruling despite multiple changes to copyright law attempting to keep up with new distribution methods. The core of the ruling, that distributing copies of information contained in scholarly journals is fair use, was affirmed in the more current 2002 TEACH act.

Campbell vs. Acuff-Rose Music Inc.

This case is often referred to as the “the parody case,” because the major ruling in this case is that parody is considered to be transformative and therefore not an infringement of copyright. The group 2 Live Crew created an alternate version to the Roy Orbison song “Pretty Woman,” and the Orbison estate sued on the grounds that they still held the copyright.

This case was ruled on in 1994, largely before the rise of digital music distribution, and is foundational for a whole sub-genre of music by the likes of Weird Al . In addition, this ruling protects parody in educational settings. An example of protected fair use under this law is when journalists, or news organizations, quote parts of publications in their job duties even though they may not have permission.

Jacobson vs. Katzer

This case is one that affirmed that individuals who release their works as open source can set rules for their usage. Jacobson developed an open source program for model trains, which Katzer later used in a product he sold. Jacobson sued saying that his open source project was protected under Artistic License, which the courts agreed.

The larger ramifications for this case are that even when software is released as open source there are still copyright questions to be considered in its usage. It also protects open source work with a monetary value from being copied and distributed by others without proper licenses and usage agreements, which in this case were outlined beforehand.

A.V. vs. iParadigms LLC

This case affirmed that fair use could involve whole works should the usage be considered transformative enough. The defended iParadigms created an anti-cheating software that archived all student works submitted and compared each new submission to its expanded archive. Students sued saying iParadigms’s holding of their work was copyright infringement, but the courts ruled that using the works in a completely different context, anti-cheating, was considered transformative.

The larger ramifications for this case are that it expands the principle of transformational use beyond that of parody and opens up multiple avenues of usage for copyrighted material so long as the usage is significantly different than the original intent. In addition, the ruling mentioned that while there were negative effects to the students – in that the aftermarket for their papers was diminished – copyright law was not concerned with protecting copyright holders from this secondary harm.

Cambridge University Press et al. vs. Patton et al.

This case ruled that Georgia State University's usage of excerpts from journals made available to students in a special course reserve without explicit permission from major publishers was considered Fair Use in almost all cases brought by the plaintiffs. What that means is that Fair Use applies to digital distribution of 'large parts' of works in an education context.

The larger impact of this case is to follow the prevailing wisdom about "printed course packs" where an outside source would print the files that the university legally had permission to use and sell them to students at a mark-up. The appeals process of this particular case may cause the Supreme Court to address this issue again.

Avoiding Copyright Infringement

Under the terms of the Sonny Bono Copyright Extension Act, all material is copyrighted until 80 years after the author's death. A guideline under this rule may be to make the blanket assumption that anything produced in the last 100 years is still going to be under copyright and to inquire further before using.

Some authors choose to release the copyright on their works before the allotted time expires, and still others choose to publish their work while waiving copyright entirely. When either of these scenarios occurs – or the copyright expires naturally – the work enters into what is called the "Public Domain" where the work is then free for use and distribution in perpetuity. There are several search engine filters that will display only results that fall under this category. However, these may not be completely accurate, and it is recommended to double check before publication when using these filters.

The US office of copyright also has a semi-searchable database of registered works (indexing of files is still in progress) that can be used as a guideline for what is still under terms of copyright and what is in the public domain. This database can be found at: www.copyright.gov/records/

The public domain database, Wikimedia Commons , is also a source for media that is in the public domain. This site features both photos, video, and audio files from a variety of sources. However, some content found on this site is not available for use in publication or other activities where the user stands to profit from its usage .

An often forgotten way to ensure compliance with copyright law is simply to ask permission from the original copyright owner. Finding this original owner may pose a challenge, although using the US office of copyright reference database may provide information. Consult a legal professional as needed before publication.

Fair Use

Fair use is the legal term for when using copyrighted material may be acceptable despite its current status. There are no absolute rules that officially determine what qualifies as fair use, however, over the years the court system has applied four legal guiding principles for looking at what may qualify. The prevailing wisdom is that if three or more are met then the qualifications for fair use have been met, although this is no legal guarantee against potentially being sued. The four major standards are: purpose of use, nature of the copyrighted work, relative amount of the work used, and the effect on the market value of the work.

Purpose of Use

Purpose of use is met if the work is transformed in a meaningful way, such as in parody, or if meaningful amounts of content are added. The transformation does not have to be total, but the final result must be noticeably different than the initial copyrighted material.

An example of this is the case of *A.V. vs. iParadigms LLC* listed above. The key finding in this case was that iParadigms was using copyrighted materials for a wholly different purpose than the original author's intended usage.

Nature of Copyrighted Work

Nature of copyrighted work is focused on the knowledge value of the source in question. There is more leeway to use factual information that is under copyright for the advancement of educational purposes than there is to use whole sections of non-fiction works.

An example of this is the case of *Williams and Wilkins Co. vs. The United States* mentioned above. The key factor in the opinion on this case was the value of the copyrighted materials to further knowledge in the field of medicine.

Relative Amount

Relative amount is often mistakenly assumed to have a fixed number attached to it, but there is no official standard set for how much of a work may be reproduced and still be fair use. A common standard is "ten percent," but this rule is still largely up for individual interpretation.

An example of this is the case *Cambridge University Press et al. vs. Patton et al.* mentioned above. The key finding in this case relied on how much of each copyrighted work was being used without permission, and while the court did not set a numerical or percentage amount, it did rule that how much of the content was used was a key factor in each individual ruling.

However, relative amount may not apply when the section of the work taken is considered to be "the heart of the work" or the most important, or memorable, piece from the whole. An example of this is the court case where the song "Ice Ice Baby" was found to have taken the base rhythm line from the Queen song, "Under Pressure." Although the amount of music copied was less than ten percent, because the baseline is what made the song so catchy and recognizable, the courts found case for copyright infringement.

Market Effect

Market effect focuses on whether the usage of the material financially harms the original copyright holder. Even if the market for the new usage of the material is different than the original, if there is a case that the original copyright holder may have exploited that market, then fair use may not apply.

An example of this is the case of *Jacobson vs. Katzer* mentioned above. The key finding in this case was that Katzer had caused monetary harm by creating a competing software using the open source code.

A more detailed explanation of what constitutes each standard can be found in the chapter focusing on fair use.

Conclusion

Copyright law is deeply embedded in the field of education. As such, education is often impacted by the legal changes in copyright law. With the creation of online resources, there are many more points of access for obtaining research materials and media for use in publication; however, there are still copyright protections which need to be checked and examined even with these new means of finding material in the public domain. In addition, academic fair use is a legal issue that is continually evolving, and students should proceed with care when applying the principle of fair use as justification for use of copyrighted material.

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Design Layers

Matthew Armstrong

Instructional Design

design layers

modularity

Design Theory

I recently took my car to the mechanic, because whenever I used the brakes there was a loud thumping noise. I knew there was a problem with the brakes but had no idea what the problem was or what a solution might look like. I took it to a mechanic, and after hearing the noise a few times, he knew exactly what it was and how to address it. His understanding of the different systems of brakes, wheels, and how they worked together allowed him to diagnose and fix the problem quickly. This ability to understand underlying and interconnected systems is important in any field but particularly in educational technology.

When designing instruction, some may see a design as one single object (like how I saw my car), but there are several different functions within the instruction that can be isolated and analyzed. For example, the visual design choices of how the design looks can be separated from the choices of what content to include. This delineation is the basis for design layers, a theory explained by Gibbons (2014a) in his book *An Architectural Approach to Instructional Design*. In this chapter, I will give an overview of the design layers theory and discuss its strengths and limitations for instructional designers.

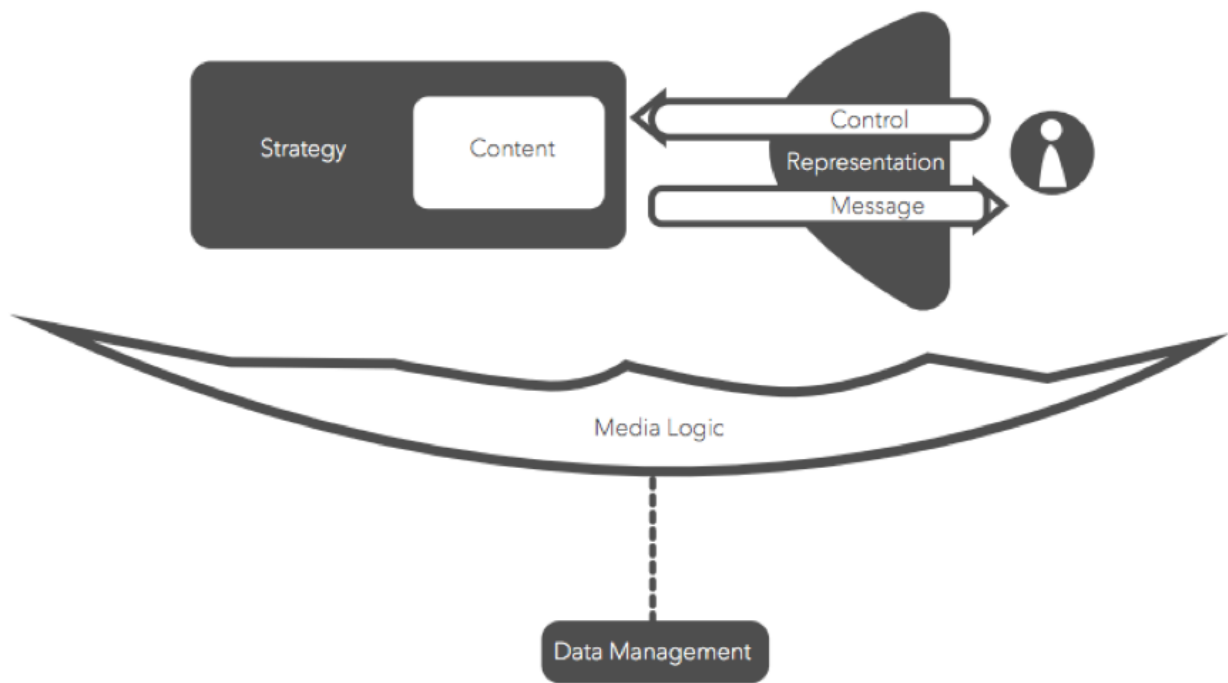
Overview

Discussing educational technological theories, Gibbons delineates between two different types: domain theories and design theories (Gibbons, 2014a). Domain theories are specific to a particular field, such as ADDIE in instructional design. Design theories, on the other hand, are not limited to a particular field and “are prescriptive in nature, in the sense that they offer guidelines as to what method(s) to use to best attain a given goal” (Reigeluth, 1999, p. 7). Design layers is a design theory in that it sets forth a framework in which multiple domain theories can be applied.

Gibbons describes seven specific layers that designers can apply to almost all instruction. While each discipline will have unique layers and sub-layers, Gibbons and Rogers make clear that the seven layers of their framework are the most general, universal, and cross-cutting principles (Gibbons & Rogers, 2009). The layers are content, strategy, representation, control, message, data management, and media logic. Figure 1 shows how each of the layers intersects with the others. The illustration emphasizes that while each layer is separate, they overlap and interact in multiple ways. In order to better conceptualize how each layer functions, I will explain them within the context of an online HTML course from Lynda.com.

Figure 1

A Visual Representation of the Seven Design Layers and How They Interact with One Another. G. S. Williams (Personal Communication, May 16, 2017)



Content Layer

The content layer is one of the most visible layers, and it consists of the subject matter, facts, or ideas that the designer is trying to convey. It does not deal with how the knowledge is conveyed but simply denotes the underlying material that will be shared. For the Lynda course, this layer would consist of the fundamentals of HTML programming such as basic tags, resources, etc.

Strategy Layer

The strategy layer focuses on the best way to convey the content or message. Technically, almost every other layer has strategic decisions, but it is important to make the distinction in how the choices are made. Designers have a particular goal and must make decisions about how to achieve that goal. Lynda.com has a global strategy for all of their lessons in the way they provide tutorial videos with additional practice files if the lesson permits it. Within that framework, each instructor would also have their own strategy layer in deciding how to format the class, the order and depth of each topic, and which exercise files to offer. In addition to instructional videos, this particular HTML course allows the use of a coding window where the user can manipulate the code and see their changes in real-time. These decisions of how to best accomplish the original instructional goal lie within the strategy layer.

Representation Layer

In responding to those choices, the representation layer entails what is seen and heard. Gibbons describes it as “the only tangible layer of a design” (Gibbons, 2014a, p. 35). Designers must choose all the visual elements and understand how those choices contribute to the strategy layer. For the Lynda course, the elements of this layer consist of visual aesthetics, video editing, presenter, and many other choices.

Control Layer

As the designer creates instruction, they provide the format in which the learner will be able to interact with the instructor or computer presenting the information. The control layer consists of these inputs and actions from the

learner that affect how the course is delivered. Within the Lynda course, users can pause, rewind, or adjust the speed of the tutorial video. They do not have to wait for a video to finish before moving on. All of these options of choice and feedback for the user make up the control layer.

Message Layer

While control deals with the choices coming from the learner, the message dictates what ideas are being transmitted from the instruction. This layer is “one side of a two-lane highway that connects learner with instruction. The other lane is the control layer. Together, the message layer and the control layer supply the channel through which instructional conversations take place” (Gibbons, 2014a, p. 37). There are direct messages Lynda has about the HTML content; each chapter title, for instance, could be seen as a message. What is important to consider in this layer is the implicit messages: mainly that the message of the designer might not be the message the student receives. For example, if the HTML course were to be extremely complicated, the instructor might think they are sending messages of detail, depth, and complexity, while in reality, the only message the learner receives is that HTML is extremely complicated.

Data Management Layer

All of these interactions produce a certain amount of data. This layer deals with how the data are recorded and analyzed. While Lynda doesn’t openly share how they track their users’ data, designers at Lynda are likely observing a wide variety of analytics, such as how many people take the HTML class and how long it takes them to complete each section. How Lynda then chooses to analyze and apply that information would all be contained in the data management layer.

Media-Logic Layer

As shown in Figure 1, media logic is connected to each layer in that it drives the coordination for all of the layers acting together. Whether the instruction will involve a human presenter, a guiding technology, or both, they each “operate according to some set of instructions—either programmed or in the form of teaching directions or teaching habits” (Gibbons, 2014a, p. 45). Acting as the shell for each of the layers, media logic defines how the representation, message, content, and data can all be packaged into one product or experience. Designers must make choices on the environment, the infrastructure, and whether or not the setting enables each layer to function. Lynda uses their video hosting software instead of linking to Youtube or Vimeo, which allows them more flexibility to execute the course according to their needs. Since users may be on a phone or laptop, their classroom setting is constantly changing, and they must be able to adapt.

Strengths

Adapting To A Changing Field

A layers view of instruction is helpful for a designer because when learning is understood on a functional level, it is much easier to adapt to a constantly changing field. New technologies and theories are entering the field at a rapid pace. The surge of technological advancement in the past decade has not only changed what materials students use to learn but has also drastically affected the way they communicate. With a layers perspective, designers are less likely to be distracted by new technology or theories, because they can delineate between what is new and what is a new manifestation of something more fundamental.

Adapting A Design

As designers evaluate their work with an understanding of layers, they can be more precise in addressing what is wrong. Like a mechanic diagnosing a car, a designer’s ability to address an issue relies on their understanding of a product’s different systems. Often a faulty design can appear to have one solution, but further investigation may show that there are multiple interconnected layers involved. Knowing each layer can expand the designer’s vision and vocabulary of the product and is useful for diagnosing problems.

Additionally, an understanding of layers can help a designer more readily adapt to new technologies. For example, if a history teacher uses a particular technology to teach a set of principles when the time comes to switch technologies, the process will be much easier if the teacher has a strong foundation in each of the other layers. The overall strategic execution might change, but the content and messages can remain intact.

Modularity

Separating design into individual layers also helps in the production process. Separating out the design responsibilities can make the process less expensive and more efficient. The computer industry thrived on this model in the 1960s (Gibbons, 2014a). Stepping away from one all-encompassing machine, companies began producing individual parts, such as RAM and the hard drive, that could be switched out, allowing for cheaper parts and better testing of new ideas. Similarly, within instruction, designers can produce more work by focusing on individual layers. Visual templates can be mass-produced, allowing enough flexibility for a variety of content inputs.

Limitations

No Linear Direction

If a designer focuses solely on layers, it will be difficult to efficiently move through the design process as there is no concrete step-by-step sequence to follow. This is difficult for companies that need linear and straightforward processes to keep moving products along. Care must be taken to have a reasonable balance of layer theory within project management principles.

Furthermore, since each company or educational institution has a distinct environment with unique needs, it can be difficult to know which layers to focus on. Gibbons (2003) asks the following:

Is there a right layer priority in designs? Should designers always be counseled to enter the design task with a layer in mind? It is not possible to say, because design tasks most often come with constraints attached, and one of those constraints may predetermine a primary focus on a layer. (p. 24)

This lack of specificity in application can be a hindrance to adoption as it can be difficult for a designer or a company to use the ideas long enough to understand how the layers apply to them.

New Theory Drawbacks

While Dr. Gibbons has been writing journal articles about design layers for several years, his book that explains the architectural approach has only been out since 2014. The recency of the concept can also be a limitation. It often takes time, particularly in the education field, for new theories to be accepted and applied. As scholarly discussion progresses, ideas are tested and refined, allowing more people to see how a theory might apply to their specific situation. If the theory is not consistently used, it might become increasingly difficult to apply the principles in a constantly changing field.

Conclusion

Despite the limitations of the design layers theory, it is an important concept for instructional designers to understand. While too much focus on the theory can limit the clarity in a process, it can likewise be limiting if a designer views their instruction without recognizing the delineation between layers. Particularly as the field progresses, there will be a high demand for designers who don't just know these layers but know how to recognize new layers. "A designer to an increasing extent will be required to be a problem solver who understands where new value is for the provider, the producer, and the consumer, and who is constantly looking ahead for opportunities to bring value to all of them" (Gibbons, 2014a, 409).

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Gamification

Alyssa Erickson, Jeanine Lundell, Esther Michela, & Phillip Isaac Pfleger

All too often traditional school is perceived as boring or inefficient by many students (Dicheva, Dichev, Agre, & Angelova, 2015). In an effort to combat this problem, teachers look for new ways to motivate and engage their students in learning. One way of addressing this problem is through gamification, which is a rapidly growing approach in education due in part to advancements in technology. Research on gamification and its applications in K-12 and higher education has grown over the years, but there is a need for further research, especially in the K-12 setting (Dichev & Dicheva, 2017).

Most people are familiar with the concept of games, so the term “gamification” is probably familiar. A game can be described as a system that allows players to engage in an abstract challenge, which involves defined rules, interactivity and feedback; ends in a quantifiable outcome; and may elicit an emotional response (Koster, 2004). Simões, Redondo, and Vilas (2013) list additional game elements that are relevant to K-6 classrooms, including the following: encouraging repeated experimentation, breaking tasks into subtasks, adapting tasks to skill levels, allowing different routes to success, and giving recognition or rewards. Gamification involves using these types of game design elements in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2014), such as the classroom. In this chapter we will focus on gamification in K-12 classrooms by providing (a) a brief history of the origin of gamification, (b) justification for gamification, (c) practical applications of gamification for teachers, and (d) cautions to consider when applying gamification to learning activities.

Origin

The term “gamification” originated in 2008 within the digital media industry (Deterding et al., 2014), but using game design elements in a non-game context started long before the term was used. When you were in elementary school, did you ever have a chart where you added stars for every book you read, and at the end of the month the student with the most stars received an award? Whether an effective learning activity or not, the star chart was an example of adding game elements to a non-game context. Teachers in traditional classroom settings naturally incorporate game elements to classroom learning to increase student motivation and engagement.

In the digital age, teachers often gamify classroom activities through the use of technology. For example, technological tools such as Class Dojo aid teachers with classroom management and communication as they award points for good behavior. Digital badges are visual representations of achievement that are available online and contain rich metadata as evidence of the achievement; they are often combined with points and leaderboards to gamify learning (Gibson, Ostashewski, Flintoff, Grant, & Knight, 2015). Students may use clickers or smart devices to answer questions in gamified response systems such as Kahoot! or ActivInspire. Technology tools facilitate gamification by providing a framework for teachers to quickly and more easily add elements of gameplay to the classroom.

Defining Gamification

In this chapter, we define gamification as the incorporation of elements of game design in a classroom setting. The goal of gamification is to use these elements that are game-like, or fun, to create meaningful learning experiences (Kapp, 2012). In creating these meaningful learning experiences, gamification in education has the potential to motivate and engage students during the learning process.

Motivating and Engaging

Gamification includes elements that stimulate both extrinsic and intrinsic motivation. Intrinsic motivation in a classroom manifests itself when students are inherently interested in the content (Ryan & Deci, 2000). Teachers generally want their students to be intrinsically motivated. However, not all classroom tasks are inherently interesting or enjoyable to all students. To address this, game elements can be added to increase extrinsic motivation, which is behavior driven by external rewards. Kapp (2012) asserts that the value of extrinsic motivation should not be dismissed. Research studies show that extrinsic rewards can foster intrinsic motivation. For example, intrinsic motivation is fostered when gamification elements “work to increase a feeling of agency and ownership” (Stott & Neustaedter, 2013, p.13), which can help to increase interest and enjoyment.

The excitement and engagement that accompany gameplay is almost universal for all ages but especially for younger students. Simões, et al. (2013) put it this way:

The gamification of education approach has the advantage of introducing what really matters from the world of videogames – increasing the level of engagement of students – without using any specific game. The aim is to extract the game elements that make good games enjoyable and fun to play, adapt them and use those elements in the teaching processes. Thus, students learn, not by playing specific games but they learn as if they were playing a game. (p. 3)

Let’s try this out on you, as a reader. Within the next ten seconds, think of at least five words that rhyme with “learn”. Ready? Go! 10, 9, 8, 7, 6, 5, 4, 3, 2, 1. Likely, you felt a sense of urgency and focus as you either wrote or thought about these rhyming words. You may be feeling ready to design a gamified learning experience for the classroom. First, we must address a couple of common misconceptions about gamification.

What Gamification is Not

Many people write or talk about gamification based only on their background knowledge, due to almost universal familiarity of how games work and engage players. This leads to misinterpretation of the term “gamification” and confuses it with other concepts. We will address this messiness before we approach the practical application section.

Game-based learning. Oftentimes, the terms “gamification” and “game-based learning” are used interchangeably, when their meanings differ significantly. Perrotta, Featherstone, Aston, and Houghton (2013) define game-based learning as “the use of video games to support teaching and learning”. These are often used to teach or apply specific information and skills. Although video games can be important learning tools, simply bringing a game into the classroom is not gamification. Recall that gamification extracts and uses elements of games to enhance non-game environments, like the classroom.

Badges, points, and rewards. Effective gamification in education is not simply adding game elements like leaderboards and reward systems with the expectation that students will suddenly learn more. Students do not play games for the points alone, but also for the engaging play, the feedback, and the sense of accomplishment that comes with working hard to master a task (Kapp, 2012). Learning activities that are poorly or inappropriately designed will lead to the overall failure of gamifying the classroom (Winoto & Tang, 2015). For this reason, the rest of this chapter aims to help K-12 teachers design effective learning experiences using gamification.

Common Elements for Successful Classroom Gamification

There are many elements of game design with innumerable possible applications in the classroom. As every teacher must learn, what works in one classroom for one teacher with a particular set of students may not work for another teacher with different students. Incorporating game elements into effective teaching and behavior management strategies will require time for thoughtful preparation, experimentation in implementation, and periodic reflection and adjustments. Research into the effective implementation of gamification is still relatively scarce, especially in the K-12 setting.

Authors studying game-based learning and gamification use different terms to describe similar game elements. Stott and Neustaedter (2013) identified four elements that were consistently successful when applied in the classroom: (a) freedom to fail, (b) rapid feedback, (c) progression, and (d) storytelling.

Freedom to Fail

Much has been written in recent years about building resilience and persistence in the face of setback and failure (Duckworth, 2016; Dweck, 2008). Freedom to fail means giving students the chance to experiment and fail without pressure or fear of irreversible damage (Stott & Neustaedter, 2013). Video games incorporate this element by offering players multiple lives and opportunities to start from a check-point, rather than at the very beginning each time. Failure can be presented as a necessary step in the learning process rather than being seen as a final destination. In a classroom, having the freedom to fail is important in maintaining student motivation, because it encourages experimentation in problem-solving and fosters persistence through difficult tasks. Related to this idea of freedom to fail is the freedom to choose, or the opportunity to decide one's own path to reach the goal.

One attraction of games is that they allow players to choose both missions and the path to success. These choices require problem solving and lead to natural consequences, from which the player can learn for future attempts. Having agency and autonomy is an element of gamification that can increase engagement and intrinsic motivation in students as they take ownership of their learning and monitor their own progress (Tu, Cherng-Jyh, Sujo-Montes, & Roberts, 2015).

In a classroom, the freedom to fail and to choose can be implemented in many different ways. It can begin with the teacher's attitude. The teacher sets the tone for the class and can emphasize to the students that getting things wrong is a part of learning and not necessarily a bad thing. How a teacher models the learning process and responds when students struggle to understand will affect how students view their failures and ability to learn in the future.

Frequent, low-stakes formative assessments, which may already be a part of a teacher's pedagogy, can be an effective way to incorporate the freedom to fail element by gauging understanding without the pressure of grades. These assessments can take many forms including ungraded quizzes, explanations to peers, and using hand signs to indicate answers. One way to provide the freedom to choose is to give students different options to show mastery of a skill. For example, instead of assigning certain spelling tasks each night, a teacher might provide a list of possible spelling activities to be completed over the course of the week, with each activity being assigned a certain number of points. By the end of the week, each student must complete enough activities to earn the required number of points. This allows students to choose the course of their learning while promoting mastery of the content.

Rapid Feedback

Feedback is an integral part of learning in our education system and is important for both the teachers and the students (Stott & Neustaedter, 2013). Rapid feedback allows teachers to gauge the student's current understanding and make instructional decisions in the moment. It also allows students to evaluate their own learning, see the results of their efforts, and make decisions about strategies and next steps. Immediate feedback, especially when paired with repeated chances to implement that feedback, can be an effective learning tool (Simões, et al., 2013). In games, immediate feedback can be seen in earning points, advancing levels, unlocking achievements, earning badges, and moving up on a leaderboard. Take into consideration that gamified feedback can be provided for making academic progress as well as for meeting behavior expectations. Providing feedback can be implemented in a variety of ways.

Technology tools exist that can make it easier for a teacher to record and quickly analyze student answers. Classroom response systems (i.e., clickers or other electronic feedback devices) have become more readily available in many schools. Teachers can prepare questions or quizzes in advance or create a class poll in the moment. While technology can make immediate, individualized feedback easier, there are other ways to provide feedback as well. Teachers can provide immediate feedback in written and verbal forms. Peer feedback and input can also be effective in helping students gauge their own progress.

Feedback in the form of leaderboards or progress charts can serve to motivate students in various tasks. There are examples of school-wide leaderboards for reading books and mastering math skills, and even for measuring the progress of fundraising competitions. Leaderboards provide a visual representation of accomplishments, provide recognition, and, in theory, provide motivation for other students.

One teacher applied both the freedom to fail and rapid feedback elements while teaching a college psychology course. The course involved a two-day unit on statistics, one of the more potentially boring portions of the class for many of the students. For several semesters this unit was conducted as a lecture, which consistently led to increased absences and social media usage during class, so a follow-along approach was employed. The follow-along approach yielded little benefit, however. Finally, a gamified approach was taken, in which a mystery was presented to the students in several rounds and data sets. Each round required students to submit a summary of their findings, which were only accepted when the students had met the learning objective for each round. This led to many iterations on behalf of the students and instantaneous feedback. An analysis of student perceptions showed that students thought more highly of statistics after participating in the game. Furthermore, they were less worried about failing and were more willing to ask questions. Overall, the activity gave them a sense that they could learn statistics.

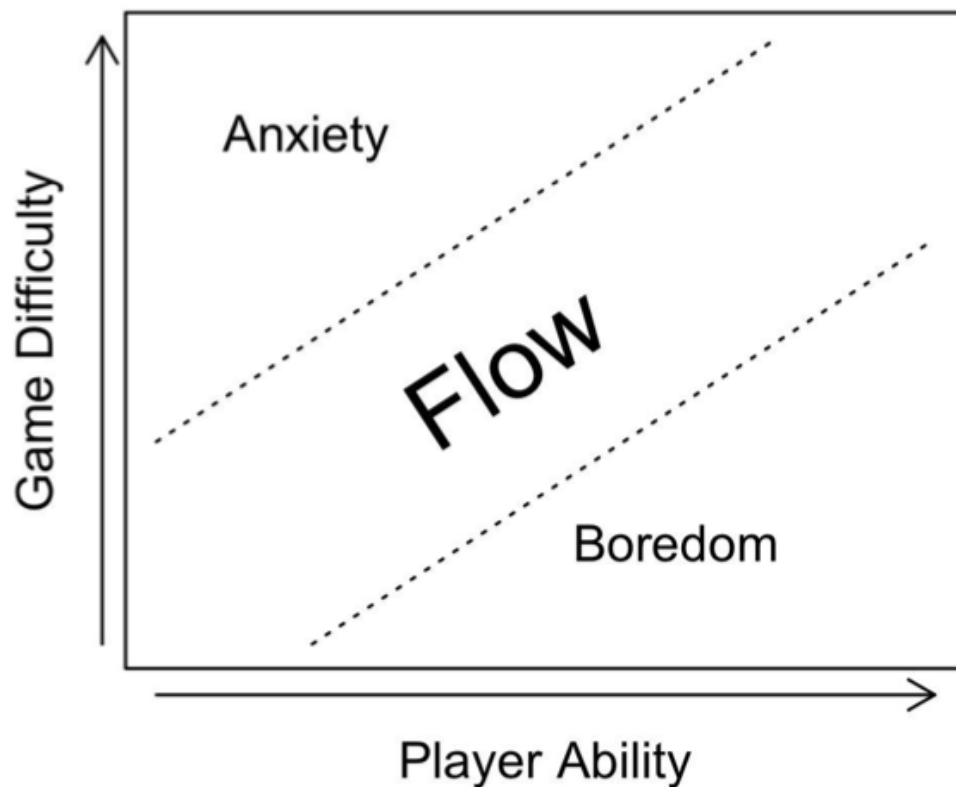
Progression

Progression is another element of game design that often leads to success in the classroom. Progression gives the player the impression of advancement by (a) increasing the difficulty of obstacles (e.g., more capable opponents, limited resources, more complex missions) and (b) enhancing the player's ability (e.g., extra resources, new powers, leveling up, experience, increased skill) (Stott & Neustaedter, 2013). These obstacles and enhancements often serve to keep the player "[operating] at full capacity" (Nakamura & Csikszentmihalyi, 2014, p. 90). This phenomenon is known as being in flow (Figure 1).

It may be possible that the dynamics of game progression encourage students to be in Vygotsky's zone of proximal development as well (Chaiklin, 2003), since scaffolding is associated with the principle of progression (Stott & Neustaedter, 2013). This would also imply a balance between what is asked of students and the resources provided for them to succeed.

Figure 1

Games and Flow Theory. Limitations Such as Resources, Levels, Etc. Work to Keep Game Players in Flow.



Take a moment and consider a game you have played recently. In what way did the game progress? Did the challenges become increasingly difficult? Were you more capable of success by the end of the game than at the beginning? Examine the following examples of progression applied to the classroom, and consider how you might incorporate this principle into your teaching efforts.

One professor incorporates progression by the passage of “years” in a simulation he has designed. In the simulation, students are required to make decisions for a country as if they were the governing body. They are responsible for balancing public opinion, carbon emissions, stability of the economy, and money. In order to play the game, students must do the basic homework. Students are able to write reports for bonuses within the simulation, which have increasing requirements as the semester goes on.

Another way to incorporate progression may be in the form of badges. Badges in this setting are much like they are in the Boy Scouts. They represent skills that a student has shown they possess. Khan Academy is one example of using badges to encourage progression in academic skills, as well as in behaviors such as persistence. Students can earn points and badges for small academic achievements, such as completing 3-5 math problems correctly in a row, or for large achievements, such as mastering a set of skills. Extra badges are awarded for persistence through difficult tasks. For example, when a student struggles with a skill, they can earn a badge for watching an explanatory video on that topic. Khan Academy encourages regular use of the program by giving badges for logging in every day for a week or month. Student progression in different areas of a classroom can be acknowledged using badges.

Storytelling

A well-made story in a game draws players in and compels them to move forward. Likewise, in an educational setting, story functions as a way to put learning into a meaningful context, thus increasing engagement and motivation (Stott & Neustaedter, 2013). According to Brandon Sanderson, New York Times Best Selling Author, the most important principles of storytelling are character, setting, and plot. These are held together by the conflict of the story (BYU English, 2014). For example, consider a familiar story where the main character is a small yellow blip on a screen. The

setting is a neon maze filled with Pac-Dots, which our hero, Pac-Man, is determined to devour. However, ghosts haunt this labyrinth and are after our hero. The player must navigate Pac-Man through the maze, while avoiding danger and eating Power Pellets for a distinct advantage over the ghosts. All of this is weaved together in the continual pattern of eating, running, and fighting that is characteristic of the Pac-Man series. The same principles of story that have pulled generations of players into Pac-Man may be applied just as effectively to the classroom.

Consider, as an example, a class driven by a semester-long consulting project. The setting is the classroom, the characters are the students and teacher, and the plot is driven by the need of a client. After an initial presentation of the client problem (i.e., the conflict), every moment in class is directed toward devising a solution. Consequently, learning occurs in an authentic context. An application of storytelling does not require warlocks or ninjas to be successful. Here the story was provided by simply giving the students a reason for their learning. This goes to show that a story does not need to be fantastical or to begin with "Once upon a time." Instead, good use of story may be as simple as providing a meaningful problem to solve with the learned material.

Cautions

Gamification can be useful in motivating and engaging students in K-12 classrooms, but there are times when gamification should not be used. Karl Kapp (2013) in his book *The Gamification of Learning and Instruction Fieldbook: Ideas into Practice* offers several "wrong" reasons to use gamification.

Just because something is cool, fun, and popular does not mean it will lead to learning (Kapp, 2013). Be on the lookout for this "wrong" reason when making the decision to gamify something in the classroom. PBL (points, badges, leaderboards) are the most commonly implemented aspect of gamification, though often without justification (Dichev & Dicheva, 2017). Neither the fun factor, nor the popularity factor (e.g., other teachers are using gamification) should be the driving force behind using a gamified approach for an interactive learning activity.

Deciding to gamify a learning activity on the assumption that everyone loves a game is another "wrong" reason to use gamification (Kapp, 2013). Evaluating the audience that will be participating in the activity is an important step in the design process. Some students love games and competition, but others do not. Instructors should use an approach that will appeal to their specific group of students.

Using gamification with the idea that students will play the game and never know that they are learning is not a good justification for gamifying a learning activity. Research shows that students retain information longer when they know what they are learning (Kapp, 2013). Gamification should highlight the lessons learned. Pre-discussion and post-discussion about concepts learned in the gamified activity are important to consider.

Some instructors choose to gamify activities in the classroom, because they think it is easy. It is not. Designing gamified activities that meet specific learning outcomes is challenging. It requires a large amount of planning beforehand and thoughtful consideration of the desired outcomes of the activity.

Conclusion

Gamification uses game elements in a classroom setting to increase motivation and engagement. Teachers naturally use game elements in classroom activities, and the digital age has increased the technological tools that are available to do so. Currently, more research is needed in the realm of gamifying K-12 education, where only a limited number of studies have been published (Dichev & Dicheva, 2017). However, there have been four game elements identified that can help a K-12 teacher to successfully gamify learning activities in the classroom: (a) freedom to fail, (b) rapid feedback, (c) progression, and (d) storytelling. While implementing these game elements in the classroom, teachers should purposefully consider what will best help their student to learn. When teachers thoughtfully gamify their classrooms, they are likely to see an increase in student motivation and engagement.

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Informal Learning

Justin R. Evans, Matt Karlsven, & Spencer B. Perry

Much of the learning that we experience as human beings occurs outside the realms of formal education and is classified as informal learning. Most of what we learn from birth about speech, cultural norms, spacial awareness, and social cues comes from personal experience and a personal creation of knowledge. Some scholars believe that at least 80% of learning in the workplace is classified as informal (Watkins, Marsick, & Fernández de Álava, 2014). Knowing how all-encompassing informal learning is, we believe that it is important for both practitioners and researchers to gain a better understanding of what informal learning is and how it works. In this article, we give a description of some of the key characteristics and components of informal learning and compare and contrast them to the characteristics and components of formal learning. We conclude by addressing some of the challenges and techniques of evaluating and measuring informal learning.

Definitions of Informal Learning

Various definitions of informal learning exist in the research literature, often overlapping with definitions of other learning terms (Manuti, Pastore, Scardigno, Giancaspro, & Morciano, 2015). The Organization for Economic Cooperation and Development (OECD) defines informal learning as not organized in any way (n.d.). Richardson (2004) points out that informal learning does not generally lead to formal qualification, and Conlon (2004) points out that this type of learning occurs through incidental, everyday experience. Some have suggested that informal learning in the workplace is any unstructured learning that occurs in order to become capable of performing professional duties (Merriam, Caffarella, & Baumgartner 2007; Yanchar & Hawkley, 2014). We will present aspects of learning that we believe make a learning experience informal. We will also discuss the nature of defining a learning experience as either formal or informal and establish a framework for classifying learning experiences as such.

Spectrum of Learning. Many theorists and designers carry a categorical view of informal learning, defining it simply as learning that is not formal (Colley, Hodkinson, & Malcolm, 2002; Manuti et al., 2015). Eraut (2010), however, describes informal learning not as a category of learning but rather as one end of a spectrum of learning, with formal learning being at the other end of the spectrum. Others support this view that informal learning is related to formal learning by a gradient of learning formality (Sefton-Green, 2004; Straka, 2004). We also support the view that the formality of a learning experience exists as a spectrum rather than as a dichotomy of formal or informal. We will discuss this view in greater detail in later sections.

Aspects of Learning

While learning can be described in many ways, we will examine what we consider to be four key aspects of learning that help us to identify the degree of formality in a learning experience. These are adopted from Malcolm, Hodkinson, & Colley (2003) and include learning process, location and setting, purpose of learning, and content. In analyzing the formality of a learning experience, we suggest analyzing each of these key aspects separately and then considering the experience as a whole (see Figure 1). In the following sections we will discuss evaluation of the formality of each of the four previously mentioned aspects of learning.

Learning process. The formality of a learning process describes the amount of structure that makes up the learning experience. In the most formal of learning experiences, an individual or group external to the learner (i.e., a teacher) presents learning objectives, a plan for achieving objectives, and assessment strategies to learners (Eraut, 2000; Folkestad, 2006). This process is reflected in most public K-12 education settings as well as most higher-education settings where teachers and students fulfill their traditional roles of giver and receiver of information. The process of learning is sometimes formal in workplace settings as well. When an employee completes a corporate-mandated harassment training, for instance, they are experiencing a learning process that is formal, because the objectives, curriculum, and assessment are highly structured and given to the employee by their employer.

A learning process that is informal is one in which the learning occurs with a low level of structure (Malcolm et al. 2003). An example of a less formal learning process might be a secondary school student who meets with their teacher to get help with a math problem outside of regular school hours. Another example of an informal learning process might be a professional employee who seeks out help with a project by watching an online video tutorial. In both cases the learning occurred in a situation in which the formal process of teacher to student knowledge transfer is less pronounced.

Location and setting. Learning within a school or college is usually considered formal while learning done outside of these situations is considered informal (Malcolm et al. 2003). Marsick and Watkins (2001) as well as Manuti et al. (2015) describe informal learning as being held outside of a formal classroom context, including both intentional and incidental learning. Most work situations resemble formal learning settings in the sense that workers gather at an established location to accomplish their work in a highly structured setting. Billett (2002) argued that work settings should be described as informal even though they maintain a high degree of structure. Manuti et al. (2015) suggest that informal learning in the workplace is integrated with daily routines, which implies that informal learning does not require a change from the location or setting of one's usual day-to-day routines.

Purpose of learning. Malcolm, et al. (2003) identify two categories in which the purpose of a learning experience can be evaluated. These are an evaluation of learner intent and an evaluation of politics surrounding the learning experience. Learner intent describes what the goals of learning are while politics describes the source of the learning goals.

Learner intent. Manuti et al. (2015) described informal learning as being influenced by chance and not highly conscious. Others suggest that intentionality and consciousness of learning may or may not be present depending on the type of informal learning that is being done (Merriam et al. 2007). For example, two forms of informal learning, self-directed learning and socialization, could be different in terms of intentionality and consciousness of learning. Self-directed learning could include conscious and intentional learning, while tacit learning or socialization might have no intentional or conscious learning. For example, someone making a goal to learn Spanish is likely intentionally and consciously choosing activities and experiences in order to improve in speaking Spanish (making flashcards, participating in conversations in Spanish, watching television in Spanish, etc.), and this resembles self-directed learning.

Tacit learning might happen when a person moves in with someone from another culture and eventually starts eating similar food as their new roommate or participating in similar activities (like watching a particular sports team) without doing so on purpose or even realizing that a change is happening. With incidental learning, another form of informal learning, a learner might become conscious of unexpected learning that is taking place, but there was no intention of it, as the real intent was to accomplish some other goal or object. For example, the person going to a shoe store might have no intention to do anything but buy a pair of running shoes but then comes to learn that there are many different kinds of shoes that offer different amounts of traction and ankle support depending on the type of activity for which the shoe is designed. That person might also unintentionally come to learn the life story of the salesperson assisting them, which would also be considered incidental learning.

Malcolm et al. (2003) describe formality of learner intent as a situation in which the learner has a specific goal in mind while informality of learner intent includes situations in which the learning is incidental to the learning goals. For example, an individual attempting to repair a vehicle may seek a video tutorial to complete the repair. This represents formality of learner intent because the tutorial was sought out with a specific purpose. If the same individual happens to

discover a trick for removing an overtightened bolt in the process, that experience is more informal, because the learning was not part of the original intended learning outcome.

Political. The political aspect of the purpose of learning refers to whose purposes lie behind the learning goals and curriculum (Malcolm et al., 2003). In formal learning experiences, an instructor might give direction to learn a specific piece of content. This is opposite of previously mentioned self-directed learning where the learner maintains control of learning goals and is able to initiate the learning experience (Livingstone & Ontario Institute for Studies in Education, 2001).

Others have described the political aspect of informal learning as situations that could include “implicit, unintended, opportunistic and unstructured learning and the absence of a teacher” (Eraut, 2010, p. 250). However, while a formal teacher or facilitator might be absent in informal learning, a learner could seek out others with expertise or insight into a particular topic (Manuti et al., 2015). Entrepreneurs and small-business owners may seek to further their education and personal growth by seeking out coaches or mentoring communities which support and encourage informal learning. Business owners and managers are more likely to participate in informal learning through discussions with suppliers and customers than to participate in formal training (Halliday-Wynes & Beddie, 2009).

Content. Content refers to knowledge gained by the learner. Malcolm, et al. (2003) state that learning can be highly informal or highly formal depending on its intent for the learner. The acquisition of informal content generally occurs when the learning experience is exploratory in nature, allowing the learner to take an active role in the creation of knowledge. These experiences include but are not limited to exploratory field trips, workplace competence, everyday practices, developing sound arguments, kindergarten level math/science/arts, and PHD level math/science/arts.

The acquisition of formal content refers to what is learned from either expert knowledge, understanding, and practices, or propositional or vertical knowledge. Efforts from governments to standardize content learned in the education system is an example of an attempt to formalize learning. Propositional knowledge is often exemplified in religions that pass down strict doctrines, customs, and truths. Vertical knowledge refers to data gathered about specific industries: their operations, actors, issues, and trends. Examples of these specific industries include healthcare, education, government, insurance, and automotive (Quayle, 2012).

Determining Formality

The framework above can be viewed as a tool for determining the formality of a learning experience. Each aspect of learning is evaluated separately and then considered as a whole. Consider the learning experience of a home mechanic who is attempting to replace a part inside of a car’s engine but does not know how to accomplish the task. In order to learn how, the mechanic finds a video online made by a YouTuber who specializes in auto mechanic tutorials. The home mechanic watches this video in their garage while working on the car, completes all of the steps in the tutorial, and successfully repairs the car.

We are interested in determining the formality of a learning experience like that of our home mechanic. The learning process is rather informal. The instructor (the YouTuber) is not present, and the mechanic may pause and rewind the video multiple times. The mechanic may even pause for meals or sleep depending on the complexity of the repair.

The location and setting of the home mechanic’s learning experience is also rather informal. The learning takes place at home in the garage, but the formality of the experience may increase if the home mechanic were to take a part to an auto shop to receive help from a professional mechanic.

The purpose of the home mechanic’s learning experience is very formal. This is the case for both learner intent and the politics of the learning experience. The intent of the home mechanic is very specific. The mechanic wants to replace the engine part so they attempt to learn how. The political component of his purpose, however, is informal. No entity instructed the mechanic to learn how to make the repair but rather the learning was initiated by mechanic of his own free will. The significance of the apparent opposition of learner intent and politics is somewhat objective. They may

cancel each other out or maintain the degree of formality of one component if that component is much more significant than the other component.

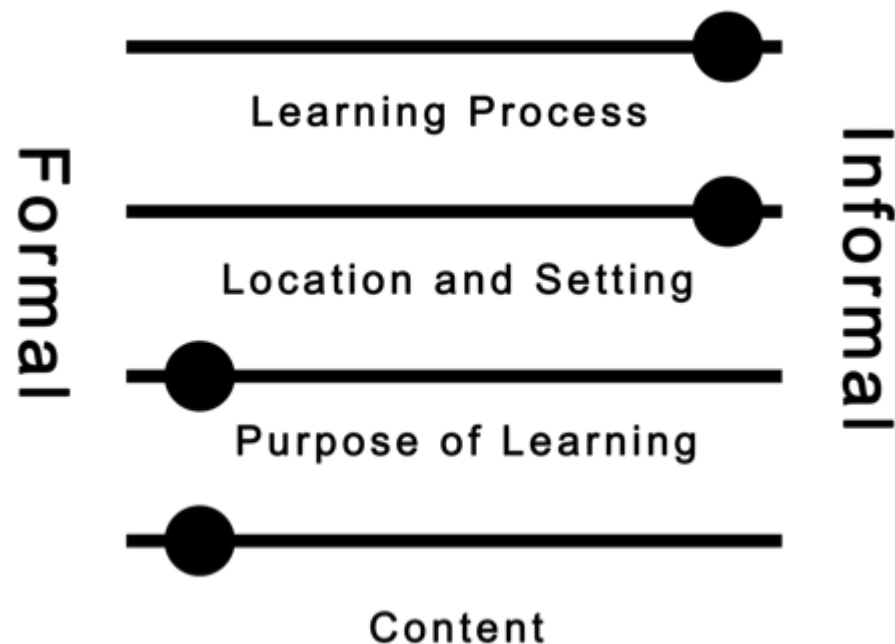
The content of the home mechanic's learning experience is rather formal. The process for replacing specific engine parts is generally established. The instructions in the YouTube video would be quite similar to those in a repair manual.

After analyzing all four aspects of learning formality for the home mechanic, we found that we easily lost track of the formality assignments we made. To resolve this difficulty, we have established a graphical representation of this framework. Each aspect of learning has a corresponding horizontal line representing a spectrum of learning from completely formal to completely informal. Each line has a corresponding marker that can be moved left and right along the spectrum.

Figure 1 contains a summary of our analysis of the home mechanic's learning experience. The placement of the markers on the spectrum is rather subjective as different evaluators would place the markers in different locations. Readers should notice that Figure 1 suggests that the overall formality of the mechanic's learning experience is neutral, neither formal nor informal. Many experiences are like this in that the formality of the experience as a whole is neither completely formal nor informal, but rather the formality of the experience falls on a spectrum of formality.

Figure 1

Analysis of the formality of a home mechanic's learning experience. The overall formality of the learning is somewhat neutral even though some aspects of learning are very formal or informal.



Evaluating and Accrediting Informal Learning

Of the articles we read on evaluating informal learning, most pointed out that evaluating this type of learning is extremely difficult (Carliner, 2012; Cuinen, et al. 2015; Falk & Dierking, 2000). Falk and Dierking (2000) argued that the difficulty in evaluating informal learning is not due to the absence of evidence but instead that informal education institutions have asked the wrong questions. They suggest evaluating informal learning should be viewed as a method of improving the process of learning and the ability of the institution to teach. Carliner (2012) and Savernye (2013)

suggest using a multiple-method approach to evaluating informal learning that includes a combination of tests and quizzes, concept mapping, recognized acquired competencies, classroom assessment, self and peer reviews, embedded assessment, performance assessment, reflective writing and media creation, rubrics, interviews, and observations. We suggest that systems such as xAPI, commonly referred to as tin-can API, have great potential for collecting data from online informal learning experiences (Brandon, 2012).

We suggest a competency based approach to learning, supplemented by low-stakes assessments and self reporting, as a way to measure and account for informal learning in the workplace and at school. Companies and schools that follow a competency-based approach ask employees and students to master pre-defined competencies (skills). Though the competencies are pre-determined (formal), the learner is given freedom to master these competencies in their own way, at their own best pace, and sometimes wherever they want (informal). Learners receive acknowledgement for their work and are able to move on to more difficult competencies only when they have mastered the lower-level competencies (Cheetham, G. & Chivers, G., 2005)

Conclusion

In this article, we have given a brief overview of informal learning. Informal learning was contrasted with formal learning on a number of dimensions, and examples have been given to further illustrate the differences between more formal and more informal aspects of learning experiences. We then discussed some of the aspects of evaluating informal learning, including some of the challenges that are encountered specifically when attempting to evaluate informal learning experiences.

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Instructional Design Methods

Justin R. Evans

An instructional design method refers to the approach a designer takes when developing a new system of instruction. Though the designer's approach may vary from case to case, many of the established methods of instructional design are similar in their fundamental nature.

The inexperienced designer may start developing a product without deliberately taking an approach. This decision can paralyze the design process (Nelson & Stolterman, 2012). Designers who take adequate time for analysis in the early stages of a project will not be as likely to face design paralysis when they receive opposition from clients, stakeholders, and peers. Having a clearly defined approach can lessen other complications in the later stages of design. If a designer adequately considers their design strategies and core learning theories early on, the product will likely have greater continuity throughout (Gibbons, 2013). The designer who puts an emphasis on the desired outcomes of a product will be more likely to design a product that meets the needs of the client. Therefore, it is strategically advantageous for a designer to have an approach or a method when beginning a new project. Novice designers should try out the approach that they feel best meets their design needs. Experienced designers should be able to implement established methods automatically and alter these methods in order to create custom solutions for various situations.

The following sections outline different methods to design: ADDIE, waterfall, rapid prototyping, ASSURE, AGILE, design thinking, and design layers. Each method is unique in its purpose and history. Each section contains a brief explanation of the method and, when necessary, a diagram and a brief history of the method. These sections are thorough enough to give the designer a basic understanding of each method, however, more reading is required on each method in order to best implement them during the design process.

ADDIE

In 1975, the Center for Educational Technology at Florida State University created the ADDIE model for the U.S. Army (Clark, 1995). The ADDIE model outlines five steps to instructional design: analyze, design, develop, implement, and evaluate. Until the mid-1980's, ADDIE was generally seen as a linear model, meaning that the designer would not move from one step to another until the previous step was completed. Nowadays, ADDIE is often referred to as less of a step-by-step process and more of a design mentality. It has a wide range of applications and forms the basis for many of the design models that are used in instructional design today (Clark, 1995).

Waterfall

Waterfall is an adaptation of ADDIE that is sequential and linear. It follows these six steps: feasibility, analysis, design, implementation, testing, and maintenance. "In a true Waterfall [design] project, each [step] represents a distinct stage of ... development, and each stage generally finishes before the next one can begin" (Lotz, 2013). Once a step is completed the designer generally does not return to that step. This application of the ADDIE model is very useful in environments that are bureaucratic in nature (like the military) where learning through failure and prototyping is not a viable option.

Rapid Prototyping

Rapid Prototyping is an adaptation of the ADDIE model that combines the design, develop, and evaluate phases. The mentality of rapid prototyping is that you need to “fail fast to succeed sooner” (Krissilas, 2012). The goal is to create prototypes quickly, gain feedback, evaluate, and create more prototypes until you have achieved your design goals. This model is useful because it is faster than the traditional ADDIE model, but it is generally weak in up-front analysis (Siemens, 2002). Rapid prototyping is useful in the business world. However, it is not the best fit in K-12 and higher education where it is often deemed unethical to intentionally prototype flawed or unfinished products on human learners.

ASSURE

The ASSURE model was developed by Dr. Sharon Smaldino, a former president of AECT. She realized that there were many aspects of the ADDIE model that would be important for teachers in the field. This model is most widely used by teachers in K-12 and higher education who have the need to adjust and design individual lessons rather than entire programs. The ASSURE model consists of the following steps: (1) analyze learners, (2) state objectives, (3) select method, media, or materials, (4) utilize media and materials, (5) require learner’s participation, (6) evaluate and revise. Each step of the process is intended to focus back on the learner’s experience. This model is extremely helpful with curriculum mapping for teachers (Grant, 2013).

AGILE

The AGILE model is an adaptation of the ADDIE model that focuses around meeting deadlines. The goal is to produce a working piece of the project with every sprint and to hit a milestone in the project at least every three months. This method encourages designers to consistently produce and discourages stagnancy in design (Agile methodology, n.d.)

This method is similar to the rapid prototyping method in that the designer develops, produces, evaluates, and repeats the process in order to create the best product available. It has similar elements as the waterfall method in that designers don’t make changes to their direction once they have started a sprint. All energy and effort is to be focused on achieving desired outcomes during the sprint. After the sprint period, designers are free to evaluate, analyze, and change their direction as needed.

Design Thinking

Design Thinking follows similar steps as the ADDIE method, but it is fundamentally different in mindset. For example, the first step to Design Thinking is to empathize rather than analyze. Before designers define what is trying to be accomplished, they need to understand their users as much as possible. The second step is to define or to pinpoint the needs and desired outcomes for the user. The third step is to ideate or to be as creative as possible in finding possible solutions or approaches to the problem. The fourth step is to prototype the ideas from the third step. Finally, the fifth step is to test; give the prototype to the original user and accept their feedback and recommendations.

This method, like rapid prototyping, has a preference toward active experimentation instead of overly detailed planning. It is encouraged in areas where designers have to be deliberate. This model is linear, like the ADDIE model and the waterfall method, and designers are discouraged to jump to the next step before they have completed the previous step.

Design Layers

Design layers is an approach that is fundamentally different than any of the methods previously mentioned. Instead of looking at design in terms of a step by step process, this method looks at a product as being made up of many different layers. This method assumes that “a designer organizes constructs within several somewhat independent layers characteristic of instructional design” (Kearsley, n.d.). In his book, *An Architectural Approach to Instructional Design*, Gibbons (2013) states that design layers are conceptual tools, generally invisible to the naked eye, and extremely useful if the designer can spot them. Gibbons outlines 7 layers in design: content layer, strategy layer, message layer, control layer, representation layer, data management layer, and media-logic layer. The designer needs to be able to conceptualize each layer and clearly understand how each layer feeds into the others.

- Content layer: This layer deals with database structure. It is the layer that “supplies knowledge elements during instruction” (Gibbons, 2013). The designer decides on the nature and structure of knowledge that needs to be learned. Also, designers decide on appropriate knowledge content for the desired outcomes.
- Strategy layer: This layer illustrates the strategy for interactions between the content and the participants. The primary “design concerns of the strategy layer [are]: goal, time, and activity” (Gibbons, 2013). Strategic goals outline what the designer and learner do to help learners reach desired outcomes. Activities and time constraints are designed strategically in order to help learners reach their maximum potential within the classroom.
- Message layer: The message layer deals with the “structure of knowledge,... [and] carries out strategic plans through conversational exchanges” (Gibbons, 2013). The message layer communicates the strategy layer and the content layer to the learner through meaningful conversation.
- Control layer: This layer “expresses the learner’s side of the conversation” (Gibbons, 2013). In this layer, learners take action by communicating back to the instruction and moving forward. The designer creates a way for the learner to take control of their learning, communicate constructively with their instructor, and collaborate with other learners.
- Representation layer: The representation layer “provides information and meaning in sensory form” (Gibbons, 2013). It is the only tangible layer of design. All other layers are intangible. In this layer the designer decides how to best represent the course and learning material in a way that appeals to the senses of the learner. This layer is one of the most important, because it impacts the intellect and the emotional state of the learner.
- Data management layer: This layer “records, analyzes, reports, and stores learning data” (Gibbons, 2013). The data management layer is vital to measuring the success and impact of the program on the learners. The designer creates the data management layer in order to provide feedback to learners, stakeholders, and developers.
- Media-logic layer: The media-logic layer “executes the operations of all other layers” (Gibbons, 2013). The media-logic layer constantly determines ‘what comes next’ during instruction. This can occur through the instructor, online media, or some other means thought of by the designer.

Conclusion

Each method of instructional design is created for a unique purpose. Designers must learn about methods, experiment with them, and decide on the method that best fits their project. Once a designer has chosen a method, more exploration will be necessary in order to fully implement the method during the design process. Experienced designers will adjust and re-think their method in order to best meet the needs of their project. A well-implemented approach can help designers increase the continuity of the product, increase the success of the product in meeting desired outcomes, and avoid design paralysis. Designers should seriously consider which of these methods (or other methods not mentioned above) best fits their project before they begin.

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Personalized and Blended Learning

Micah Swartz

Blended Learning

Personalized Learning

Personalized and blended learning are approaches to learning that provide tailored educational experiences and often utilize technology. These approaches developed from a need to provide high-quality, individualized learning that could meet the unique needs of each student, and they provide flexibility and frequently include students' voices in the learning process. Pressey and Skinner, two pioneers of personalized learning, developed devices that aimed at improving learning by offering physical devices students could individually interact with. While blended learning was not formally mentioned until the late 1990s, much of what was called personalized learning has become blended learning. Advancements in the World Wide Web spurred the development of learning management software and self-directed learning apps, the latter finding widespread use in K-12 education since 2010 or so. The continual development of technology leaves room for new meanings of personalized and blended learning.

It's no secret that students are growing up and learning in a technology-saturated society, with technology infused into many aspects of life including education. In an effort to combat student engagement and motivation issues, address personalized learning trajectories, and allow for a more dynamic, responsive, and culturally relevant way of learning, educational technologies have been designed and developed (J-Pal, 2019; Patrick et al., 2013). At the forefront of this advancement comes personalized learning (PL) and blended learning (BL), education programs that have seen widespread use across America and the world (Barbour, 2018; Brass & Lynch, 2020; J-Pal, 2019; Pane et al., 2015; Schwirzke et al., 2018).

In this chapter, I will address the origins of PL by analyzing literature and research for ways PL has been defined. Next, I will delve into the beginnings of BL, examining existing literature and research to explore the various definitions and conceptualizations of BL. Before examining PL or BL, I will start by giving a brief overview of educational technology. Figure 1 provides a general timeline of the development of educational technology that illustrates an overview of significant achievements and their time points.

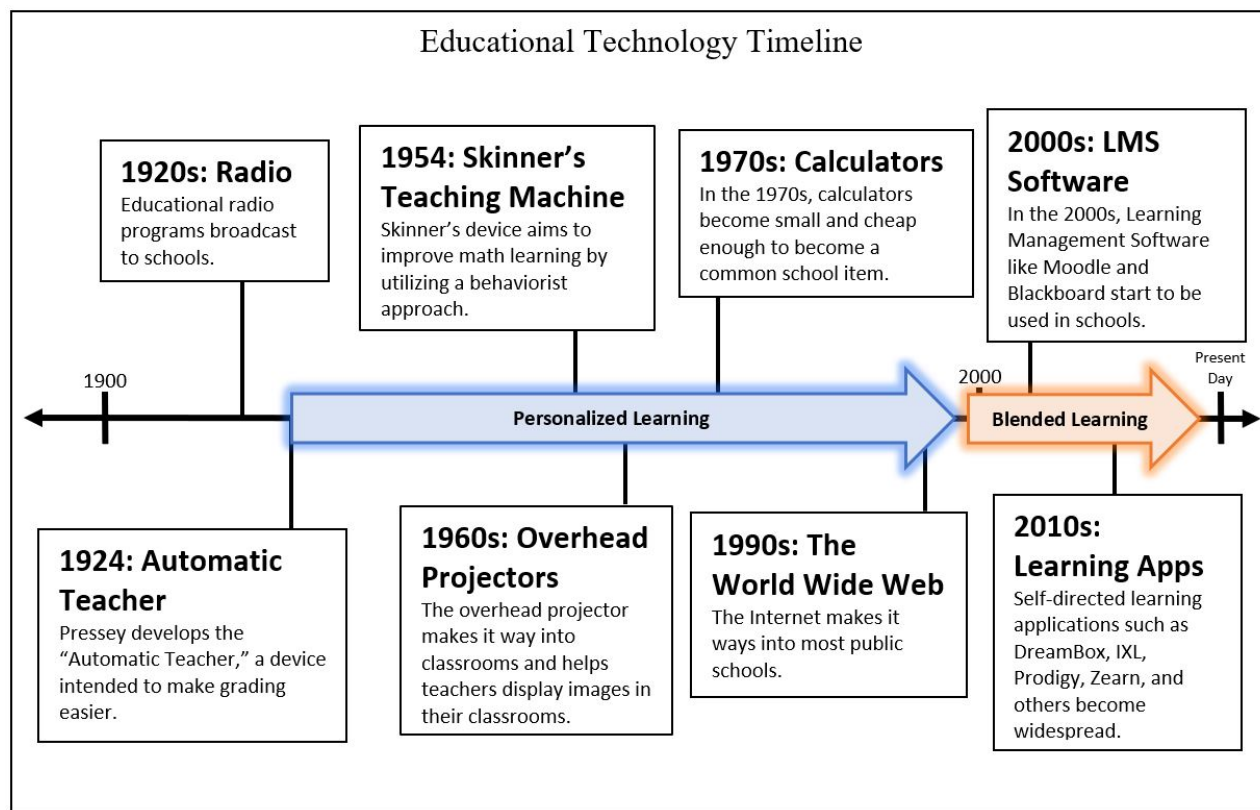
An Overview of Educational Technology

In the 1920s, educational radio programs began to be listened to in schools (Halper, 2021). Tufts University began to utilize a local radio station to broadcast lectures and make knowledge accessible to all. Other school districts and universities began producing educational broadcasts while some were uninterested. Midway through the 1920s, Pressey developed the Automatic Teacher, a device that ended as a flop (Pressey, 1926, 1963). Later, Skinner's teaching machine made a wave as it promised to offer more individualized learning and challenge students based on their

abilities (Skinner, 1958). Overhead projectors and scientific calculators were two notable technologies that had a big impact on the way teachers and students interacted and learned (Hamrick, 1996; Zimmerman et al., 2018).

Figure 1

Educational Technology Timeline



The rise of the Internet, or the World Wide Web, gave way to the development of Learning Management Systems like Moodle, Canvas, and Blackboard which profoundly changed how teachers teach and manage their students (Coates et al., 2005). As the Internet developed and its capabilities expanded, new technology and learning apps such as DreamBox, Zearn, Prodigy, and IXL became widely utilized with over 14 million students using IXL worldwide (IXL, n.d.), one in four elementary students in the U.S. using Zearn (Zearn, n.d.), and six million students in the U.S. engaging with DreamBox (DreamBox Learning, 2022). The future of educational technology continues to expand as the needs of students, teachers, and administrators change and develop.

Figure 1 also shows the timeline of personalized learning (PL) and blended learning (BL). PL started in 1924 with the Automatic Teacher and has continued to the present day. BL was first formally mentioned in the late 1990s, but much of what was called PL became BL. PL and BL are not mutually exclusive terms with the definitions of these two terms overlapping. This will be unpacked in the next two sections.

A Concise History of PL

Personalized learning (PL) and blended learning (BL) were developed from a need to provide high-quality, individualized learning that could meet the unique needs of each student (Alammary et al., 2014; Watters, 2023). In the past few decades as educational technology has developed, PL, BL, e-learning, online learning, and other names have been used synonymously (Singh & Thurman, 2019) when in fact, these terms mean different things (Graham et al., 2013). For the sake of this chapter, I will focus on PL and BL as these learning programs are two prominent technology programs in education (Barbour, 2018; Brass & Lynch, 2020; J-Pal, 2019; Pane et al., 2015; Schwirzke et al., 2018).

One of the earliest mentions of PL or BL came in the 1920s when Pressey developed what he called the Automatic Teacher (Pressey, 1926; Watters, 2023). In her book reviewing the history of PL devices, Watters describes Pressey's development of the Automatic Teacher, a device that would allow teachers to quickly grade students' exam answers. Essentially the Automatic Teacher was a testing device that kept a tally of the number of correct answers. For instance, a student would sit down next to the Automatic Teacher and on a window of the device, a question would read, "All squares are rectangles: (1) True, (2) False." The student would then hit the number corresponding to the answer they believe to be a true and another question would be presented in the window of the device. The Automatic Teacher would keep track of the number of correct questions and give that total at the end of the exam. While Pressey believed the Automatic Teacher could save schools on labor costs by decreasing the time needed to grade exams, the device proved to be too expensive for schools and full of complications.

A few decades later, Skinner created the teaching machine, a machine that utilized a behaviorist approach to learning. The device came out of an experience that Skinner had when visiting his daughter's private school in 1953. After seeing some students wriggle with boredom after completing their assigned problem while other students sat with frustration after getting stuck, Skinner decided to build a device that would offer individualized learning that could be controlled by the student. During his visit to the classroom, Skinner noticed "the students were all forced to proceed at the same pace through the lesson, regardless of their level of ability or comprehension" (Watters, 2023, p. 20). The teaching machine was invented to help students learn by reinforcement and repeated behavior management. Ultimately, the PL offered by the teaching machine was short-lived as the 1960s brought a wave of thinking called New Math which took a cognitive science approach to learning. This theory of learning went directly against Skinner's behaviorist belief which he used in developing his teaching machine.

One of the biggest worries from K-12 teachers during the emergence of PL, seen throughout Pressey and Skinner's development of PL devices, was that these teaching devices would be used to replace teachers or justify increased class sizes (Brass & Lynch, 2020). Educators and others also pointed out that the teaching machines did not teach students, rather, the devices were only able to help students with rote learning, not "real learning" (Pressey, 1963). Pressey acknowledged that "doubts have been raised as to whether human learning of meaningful material" could take place with PL devices such as the teaching machine (Pressey, 1963, pp. 2-3).

These primitive devices, the Automatic Teacher and the teaching device, soon led to more advanced technology and a new understanding of PL as cognitivism began to replace the widely adopted theory of learning of behaviorism (Brass & Lynch, 2020). While most of the PL technologies in the 20th century ended as blunders, the 21st century brought a new wave of collaborations between education agencies, businesses, government interests, and philanthropic organizations (Ball, 2012). Education agencies (e.g., Texas Education Agency, Ohio Department of Education) have taken an interest in developing PL and BL programs while big businesses such as Facebook and Google have also played a role in funding and/or developing PL and BL programs (Brass & Lynch, 2020). Additionally, philanthropic organizations like the Bill and Melinda Gates Foundation and the Chan Zuckerberg Initiative have supported educational technology companies focused on developing PL programs and software (Pane et al., 2015).

Personalized learning, or PL, is a pervasive term that has different meanings which vary based on the product it is representing and the organization or administration defining it (Shemshack & Spector, 2020). In 2013, Patrick et al. propose a working definition of PL:

Personalized learning is tailoring learning for each student's strengths, needs and interests — including enabling student voice and choice in what, how, when and where they learn — to provide flexibility and supports to ensure mastery of the highest standards possible. (p. 4).

Shortly after this definition was given, a group of educators, philanthropic organizations, and technology advocacy groups including the Bill & Melinda Gates Foundation, Afton Partners, the Eli and Edythe Broad Foundation, CEE Trust, Christensen Institute for Disruptive Innovation, Charter School Growth Fund, EDUCAUSE, iNACOL, the Learning Accelerator, the Michael & Susan Dell Foundation, and Silicon Schools came together in 2014 to create a new definition of PL that could serve as a starting point for a collective understanding of PL. They defined PL as comprised of four

pillars: competency-based progression, flexible student learning environments, personal learning paths, and learner profiles (EducationWeek, 2014). RAND researchers Pane et al. (2015) detailed that while the field does not have one shared definition for PL, there are several important attributes to look for when identifying PL:

(1) systems and approaches that accelerate and deepen student learning by tailoring instruction to each student's individual needs, skills, and interests; (2) a variety of rich learning experiences that collectively prepare students for success in the college and career of their choice; and (3) teachers' integral role in student learning: designing and managing the learning environment, leading instruction, and providing students with expert guidance and support to help them take increasing ownership of their learning. (pp. 2-3).

Interestingly, technology is not explicitly mentioned in any of these definitions but is the implied pathway to implement PL. The authors go on to explain that while these are core elements of many PL programs, due to the competitive nature of grants to purchase PL software and implement this type of learning program, schools often creatively implement PL making it look different from school to school. Pane et al. (2015) also detail five strategies present in most PL school programs, with four of the five strategies coming from the four pillars developed by the Bill and Melinda Gates Foundation and others in the 2014 meeting in which an initial definition of PL was constructed (EducationWeek, 2014). The added strategy or pillar that Pane et al. (2015) make note of is “emphasis on college and career readiness” (p. 3). This strategy posits that a PL should ensure students are developing the skillset and knowledge needed to be ready for college. This includes both academic and non-academic skills that will set students up for success in college upon graduating from high school.

More recently, the U.S. Department of Education, Office of Educational Technology released a national education technology plan that included a definition of PL. In their 2017 report, they defined PL as “instruction in which the pace of learning and the instructional approach are optimized for the needs of each learner” (p. 9). The report stresses that a PL should be based on the individual needs of each learner and be driven by the interest of learners. Moreover, the Office of Educational Technology emphasizes that activities with a PL program are often self-initiated. This emphasis on self-initiation leads to the notion of BL and how the two learning programs, BL and PL are related.

Just as there have been multiple meanings and definitions of PL (Shemshack & Spector, 2020; Singh & Thurman, 2019), there is also a cloud of mystery surrounding BL (blended learning) and its meaning (Thorne, 2013; Tucker, 2012). In connecting PL and BL, several bridges of understanding have been presented. Patrick et al. (2013) view BL as a “delivery mechanism” for PL. While they do specify that PL can be done without technology, they also note that it is “very difficult to scale PL for each student in a classroom and school without effective and meaningful applications of technology to enable the differentiation and flexibility in pacing required” (p. 14). Hence, BL allows PL to be scaled via technology such that differentiation and flexibility in pacing can be achieved. Similar to Patrick et al., the U.S. Dept. of Education, Office of Educational Technology note in their 2017 report that engaging and empowering students to learn through PL technology also affords educators opportunities to utilize BL. But what is BL? And how has it been defined? In the next few pages, I will give a historical overview of BL as I have done for PL.

A Concise History of BL

While PL has early roots that can be traced back to the early 1900s (Pressey, 1926; Skinner, 1958), BL was not first described until much later. BL is a relatively new learning program that has just begun to see widespread use (Picciano, 2006) and has often been referred to by a host of names, including hybrid learning, technology-mediated learning, web-enhanced instruction, web-assisted instruction, and mixed-mode learning (Delialioglu & Yildirim, 2007). As Graham et al. (2013) point out, BL has been often misidentified. Stein and Graham (2020) also note that there is no single definition of BL though many exist. In 1997, Moore first described what is now known as BL, but used the term “distance education” and defined it as learning that takes place when “learners and instructors are separated by space and/or by time” (p. 22). This notion of learning in a different place or time is currently acknowledged as a key tenet of BL by many educators and educational technology advocacy groups. One of the earliest instances BL was formally recognized

came in 1999 when EPIC Learning announced it would “begin offering its Internet courseware using the company’s Blended Learning methodology” (PR Newswire, 1999). Soon after, Driscoll (2002), a consultant working for IBM released a definition of BL based on extensive research that culminated in a book. She gave four different definitions for BL:

1. To combine or mix modes of web-based technology (e.g., live virtual classroom, self-paced instruction, collaborative learning, streaming video, audio, and text) to accomplish an educational goal.
2. To combine various pedagogical approaches (e.g., constructivism, behaviorism, cognitivism) to produce an optimal learning outcome with or without instructional technology.
3. To combine any form of instructional technology (e.g., videotape, CD-ROM, web-based training, film) with face-to-face instructor-led training.
4. To mix or combine instructional technology with actual job tasks in order to create a harmonious effect of learning and working. (p. 1).

In positing four definitions of BL, Driscoll noted that BL has had varied interpretations for different people. This notion was also acknowledged by Picciano (2006) who detailed that BL comes in “many shapes, flavors, and colors” (p. 96) and consequently, looks very different from classroom to classroom.

Over the past two decades of educational technology research, several characteristics of BL have emerged. Researchers have described BL as utilizing multiple pedagogical approaches (Christensen et al., 2013; Driscoll, 2002; Garrison & Kanuka, 2004; Graham, 2006; Graham et al., 2019; Picciano, 2006; Parsad et al., 2008; U.S. Dept. of Ed., Office of Ed. Technology, 2017). While some researchers have explicitly stated BL is a combination of instructional approaches (Driscoll, 2002; Garrison & Kanuka, 2004; Graham et al., 2019; Picciano, 2006; Parsad et al., 2008; Ward & LaBranche, 2003), others have described multiple approaches to learning which often includes face-to-face instruction and computer-mediated or online instruction (Graham, 2006; Jacobs, 2003; U.S. Dept. of Ed., Office of Ed. Technology, 2017). Individualized or optimized learning is another feature that has been provided in multiple definitions of BL (Driscoll, 2001; Singh & Reed, 2001). This feature has also been argued as an advantage of BL (Zhang et al., 2020).

Many recent definitions of BL (Christensen et al., 2013; Garrison & Kanuka, 2004; Parsad et al., 2008; Staker, 2011; U.S. Dept. of Ed., Office of Ed. Technology, 2017) propose online or web-based technology as a key characteristic while older definitions often don’t include this detail (Graham, 2006; Singh & Reed, 2001; Picciano, 2006). Similarly, definitions from Staker (2011) and onward emphasize student autonomy over students’ learning experience (Staker, 2011; Staker & Horn, 2012; Christensen et al., 2013; Graham et al., 2019; U.S. Dept. of Ed., Office of Ed. Technology, 2017). Often, the phrase “time, place, path, and/or pace” is used to describe the control BL gives students over their learning. This was first introduced by Staker in 2011. Table 1 lists several major characteristics of BL as suggested by different researchers. While this list is not comprehensive, it does cover nearly two decades of BL definitions and includes the most widely accepted definition.

The most notable change to the way BL was defined came when Staker (2011) defined BL as “any time a student learns at least in part at a supervised brick-and-mortar location away from home and at least in part through online delivery with some element of student control over time, place, path, and/or pace” (p. 5). This definition adds several new features to BL, all of which will be explored in the next section. Most notably, Staker’s definition underscored that students should have some control over the time, place, path, and/or pace at which they are learning with BL. Other researchers and institutions (Christensen et al., 2013; Graham et al., 2019; Staker & Horn, 2012) have adopted this tenet of BL, with the most recent definitions of BL in Table 1 extending Staker’s (2011) notion.

Table 1

Characteristics of blended learning—A Synthesis of Definitions (Chronologically Organized)

Author	Definition of <i>blended learning</i>	Characteristics across definitions				
		A combination of pedagogical approaches	Emphasis on individual/optimal learning	Technology is online/web-based	Instructional technology component	Emphasis on student autonomy over learning experience
Singh & Reed(2001)	Optimizing achievement of learning objectives by applying the “right” learning technologies to match the “right” personal learning style to transfer the “right” skills to the “right” person at the “right” time.		X		X	
Driscoll (2002)	(1) To combine or mix modes of web-based technology to accomplish an educational goal.	X	X	X		
	(2) To combine various pedagogical approaches to produce an optimal learning outcome with or without instructional technology.	X	X		X	
	(3) To combine any form of instructional technology with face-to-face instructor-led training.	X			X	
	(4) To mix or combine instructional technology with actual job tasks in order to create a harmonious effect of learning and working.	X	X		X	
Garrison & Kanuka (2004)	The thoughtful integration of classroom face-to-face learning experiences with online learning experiences.	X		X		
Picciano (2006)	A wide variety of technology/media integrated with conventional, face-to-face classroom activities.	X				

Author	Definition of <i>blended learning</i>	Characteristics across definitions				
		A combination of pedagogical approaches	Emphasis on individual/optimal learning	Technology is online/web-based	Instructional technology component	Emphasis on student autonomy over learning experience
Graham (2006)	Face-to-face instruction with computer-mediated instruction.	X			X	
Parsad et al. (2008)	A combination of online and in-class instruction with reduced in-class seat time for students.	X		X	X	
Staker (2011)	Any time a student learns at least in part at a supervised brick-and-mortar location away from home and at least in part through online delivery with some element of student control over time, place, path, and/or pace.			X	X	X
Christensen et al.(2013)	A formal education program in which a student learns at least in part through online learning, with some element of student control over time, place, path, and/or pace, at least in part in a supervised brick-and-mortar location away from home, and the modalities along each student's learning path within a course or subject are connected to provide an integrated learning experience.			X	X	X
U.S. Dept. of Ed., Office of Ed. Technology (2017)	Learning that occurs online and in-person which allows students to have some control over time, place, path, or pace of learning.	X		X	X	X
Graham et al. (2019)	The strategic combination of online and in-person learning where students	X		X	X	X

Author	Definition of <i>blended learning</i>	Characteristics across definitions				
		A combination of pedagogical approaches	Emphasis on individual/optimal learning	Technology is online/web-based	Instructional technology component	Emphasis on student autonomy over learning experience
	have some control over time, place, path, and/or pace.					

In 2011, Staker defined BL in a research report published by the Innosight Institute. This institute was later renamed the Clayton Christensen Institute for Disruptive Innovation (CCIDI), a think tank aiming to disrupt the normative ways teachers teach and students learn. The CCIDI has focused on BL for over a decade, creating an online hub called the Blended Learning Universe, which looks to support educators, policymakers, and innovators. Their most recent definition of BL is one that has received widespread recognition from many state departments of education and researchers alike. Several state agencies including the Colorado Department of Education, the Minnesota Department of Education, the Ohio Department of Education, and the Texas Education Agency have adopted tenets from Christensen et al.'s (2013) definition of BL:

A formal education program in which a student learns at least in part through online learning, with some element of student control over time, place, path, and/or pace, at least in part in a supervised brick-and-mortar location away from home, and the modalities along each student's learning path within a course or subject are connected to provide an integrated learning experience. (Christensen et al., 2013, p. 7).

In recent years, BL has been defined by the U.S. Department of Education, Office of Educational Technology (2017) as "learning [that] occurs online and in person augmenting and supporting teacher practice" where BL "allows students to have some control over time, place, path or pace of learning" (p. 10). Since Christensen et al.'s (2013) definition of BL, nearly all further definitions of BL have come from one or more tenets of this definition, but Smith and Hill (2019) point out there is still a "lack of definition, clarity and consistency" (p. 390) with BL research. Oliver and Trigwell (2005) warn that inconsistent and unclear use of BL will continue to confuse until conceptual problems are fully addressed. We can see these inconsistencies Oliver and Trigwell warn of when examining the various definitions of BL in Table 1.

Conclusion

In this article, I have given a brief overview of personalized and blended learning. A timeline for major educational technology including BL and PL was given and examples of each type of technology were presented. Moreover, I synthesized BL definitions by comparing and contrasting several key features. This article outlines the development of personalized and blended learning and the inventions that mark significant points in the development of each educational technology.

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Micah Swartz

Texas State University

Micah Swartz is a Mathematics Education Ph.D. student at Texas State University and is a 2022 recipient of the National Science Foundation Graduate Research Fellowship. Currently, he is collecting data for his dissertation which examines the relationship between blended learning and other self-directed technology and students' mathematics identity and motivation. He is passionate about research involving technology and education, and working to ensure that technology is used in a responsible and ethical manner.

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Project-Based Learning

Spencer B. Perry

inquiry

Authentic Learning

Project-based Learning

PBL

Project based learning (hereafter referred to as PBL) is an approach to instruction that is derived from the idea that students should be doing a task to aid in the learning process. More specifically, PBL includes student-centered activities that are inquiry-based and rooted in active learning. While current attitudes in public education favor education approaches with these characteristics (student-centered, inquiry based, and active learning), PBL does not apply well in all disciplines, nor do all educators choose to utilize PBL as an approach when it may be well-suited for their individual disciplines. A description of what constitutes PBL as well as a discussion of arguments for and against PBL will follow.

Origins of Project Based Learning

The origins of PBL can be traced to the American philosopher and educator John Dewey. Dewey stated:

The teacher is not in the school to impose certain ideas or to form certain habits in the child, but is there as a member of the community to select the influences which shall affect the child and assist him in properly responding to these influences (Dewey & Small, 1897, p. 9).

This sentiment expressed by Dewey is sometimes referred to as learning by doing and continues to receive support today. Researchers slowly developed Dewey's ideas of learning by doing into PBL over the last century, although the distinctions (if any) between learning by doing and PBL as well as between PBL and problem based learning are not always clear.

What is Project Based Learning?

Project based learning is thought to have different characteristics depending on who is asked. While it is probably impossible to define PBL in a way that will be universally agreed upon, definitions of PBL generally have a few characteristics in common. The common characteristics that will be described in this paper are the long-term nature of PBL, the interdisciplinary nature of PBL, and the student-centered nature of PBL.

PBL is long-term in nature, meaning that a project based learning experience will continue for days, weeks, months, or even years at a time. This juxtaposes teaching methods that isolate lessons from each other. PBL requires lessons to be interlaced together with each day's lesson requiring students to think back to previous lessons. Consequential to this style of learning is the rise of new problems to solve throughout the course of the project. These problems could delay the progression of the project as a whole. Students may have the real-world experience of lying awake thinking about the project in an attempt to solve a recent problem.

PBL is interdisciplinary. Projects draw from multiple content areas in order to create a full and complete project. This is in contrast to more typical modes of teaching, in which lessons, questions, and problems may exist entirely independent of each other. This isolation is often found both within a class and in between classes. The interdisciplinary nature of PBL includes working both within and without the course, but not necessarily across multiple courses. For example, in a classic middle school experiment students build a device to protect a raw egg when it is dropped from a high ladder onto a hard surface. If the lessons are designed with PBL in mind, they should be interdisciplinary within the course. Perhaps students discuss not only the design for a low acceleration that (hopefully) protects the egg, but also discuss the moral implications of using animal eggs as part of a science experiment. Additionally, since the lesson should be interdisciplinary outside of the science class, students might also perform a cost-benefit analysis of the protective apparatus and write a short newspaper article about the test.

PBL should be student centered, meaning that students spend the majority of the time working toward a goal and limited time focused on the teacher. Students are often in collaborative groups and manage their own time. The teacher acts to facilitate teamwork and not as a lecturer. In many ways the teacher acts like a coach, encouraging students to think critically and pursue the end goal of the project. Teachers are also responsible to assess learning from student work during the project. When learning is student centered, students play a role in selecting learning goals and approaches to achieving those goals (Hannafin and Hannafin, 2010).

Project Based Learning vs. Problem Based Learning

Project based learning is similar to problem based learning in that students work toward a shared goal, usually as part of a collaborative effort. The key difference between these approaches is that in PBL students usually work toward a solution with no single (or predetermined) solution whereas problem based learning often has a specific answer to a question. An example of PBL might be a group of students who work to design a workflow for managing the treatment schedule of patients in an emergency room. In contrast, an example of problem based learning might be a group of young doctors diagnosing patients under the supervision of an attending physician during medical rounds. The distinction between project based learning and problem based learning is sometimes made unclear in the literature of instructional design, where the abbreviation “PBL” may refer to either teaching method indiscriminately, but they are different ideas and should be treated as such.

Support for Project Based Learning

Many advocates of PBL believe that this mode of teaching is a high-engagement method that improves student learning (Krajcik & Blumenfeld, 2006) although research supporting this position is not highly conclusive. The discussion of the effectiveness of PBL is limited by an inability of practitioners of instructional design to agree on what constitutes evidence of student learning when PBL is implemented. This problem of defining evidence becomes increasingly difficult when PBL is implemented outside of math and laboratory sciences where learning is less easy to measure (Thomas, 2000).

Many practitioners of science, technology, engineering, and math (STEM) education are especially enthusiastic supporters of PBL, where funding grants for PBL are abundant. Hundreds of grants for secondary STEM classrooms are available to educators (stemgrants.com). The popularity of advocating for funding for STEM classrooms is so high that United States President Barack Obama recently discussed the need to fund STEM in the 2011 State of the Union Address (Obama 2011).

Support for PBL in STEM fields has led to the coining of the term Project Based Science (PBS). PBS is simply the application of PBL in a science classroom. In 2006, Krajcik and Blumenfeld conducted a study in which students in urban Detroit and Chicago public middle schools learned science using curriculum that included one or multiple PBS units during the course of study. Pre- and post-tests as well as performance on the Michigan state standardized assessment showed significant improvement in scores by students who engaged in one PBS unit over students who did

not engage in a PBS unit. Students who engaged in multiple PBS units showed significantly better performance than students who engaged in only one PBS unit (Krajcik & Blumenfeld, 2006). Findings like those of Krajcik and Blumenfeld may contribute to the rise in popularity of PBL in STEM classrooms. However, PBL should not be considered as a STEM-centric approach to instruction. PBL can be adapted to fit a variety of curricula due to its ability to holistically address the real-world nature of most projects.

A characteristic of PBL is that it integrates real-world situations into the learning experience. This means that instructors should seek to create an experience that is as authentic as possible for students. For example, an activity that requires students to formulate a business plan for a restaurant should include the requirement to comply with health, fire, and building codes. Some advocates in K-12 education might suggest that the real-world nature of PBL enhances career readiness in students, but research findings do not strongly support this position. This may be in part due to the difficulty of defining career readiness (Jollands, Jolly, & Molyneaux 153).

Obstacles, Limitations, and Considerations for Project Based Learning

Some teachers and administrators may be hesitant to adopt PBL because of a need or desire to closely adhere to state or district teaching standards and curriculum, and while PBL can provide rich learning experiences for students, the problems themselves may not fit very well into curriculum (Blumfield and Krajcik, 2006). For example, in the Utah state curriculum, students in high school US Government and Citizenship are expected to “determine the rights and liberties outlined in the Bill of Rights” (USOE, 2012). If a class of students were to spend two weeks developing arguments for a court hearing and then proceeded to turn the class into a full-scale courtroom, the students would likely have a rich learning experience in PBL. However, depending on the design, the learning experience might not explicitly meet the requirements of the curriculum.

The perceived disconnect between curriculum and PBL may impact assessment techniques when PBL is used. Assessing learning with PBL can be difficult due to the potential for subjectivity and inconsistency when evaluating the outcomes of PBL. Teachers may be tempted to evaluate student learning by using more traditional methods of evaluation like written, end-of-unit tests or quizzes testing small, discrete steps. The potential temptation to evaluate learning with discrete assessments may be increased for some teachers by the knowledge that their students (and to some degree the teacher) will be evaluated using written standardized assessments. This may lead to a dissonance between the way learning takes place in PBL and the way that learning is evaluated. Assessment should instead include an evaluation of the artifact or product that results from PBL (Krajcik & Blumenfeld, 2006).

Some teachers may be hesitant to adopt PBL because of the difficulties associated with classroom management. Because PBL requires high level thinking, teachers may experience lower completion rates and higher failure rates than other methods of instruction. The complexity of projects may slow lesson momentum, increase student need for help, and increase classroom disorder. Teachers may feel pressure from students, parents, administrators, or peers to reduce the complexity of the project in order to deal with these negative potential aspects of PBL. If teachers do reduce the complexity of projects in order to simplify management, then they may inadvertently attenuate the effectiveness of PBL (Blumenfeld et al., 2011)

PBL may also have negative social effects in the interaction of student groups. Social loafing may become prevalent in PBL groups. Social loafing is seen when students exert less effort toward their projects when working in groups than they do when working alone. This is seen in the Free-rider effect, where students do not put in their full effort under the assumption that other group members will compensate for the unperformed work. Social loafing is also manifest in the Sucker effect—a consequence of the Free-riders—high performing students lower their effort standards in response to the attitude of Free-riders (Salomon & Globerson, 1989). Instructors may have difficulty in combating social loafing because of the high degree of effort required to provide meaningful student feedback during PBL. Peer evaluations may help combat social loafing in PBL, but many instructors are hesitant to do so because of a perception that student

evaluations are not reliable and will address different criteria than desired by the teacher (Lee & Lim, 2012). Actual research on the effectiveness of peer evaluation in combating social loafing is not abundant.

Conclusion

PBL continues to be a popular approach to instruction, especially in public schools. In PBL, students are generally engaged in active, inquiry-based learning, and the instruction is student-centered. PBL is especially popular in STEM instruction, but its application should not be considered to be STEM-centric but rather an approach with applications across curricula. PBL may increase student engagement and scores on standardized tests, but further study is required to conclusively support these findings. PBL may also increase the difficulty of classroom management if students begin to engage in social loafing, but peer assessment strategies may help reduce such potential negative social effects.

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Reflection

Holly Fiock

The purpose of this chapter is to define reflection as an instructional method, discuss why reflection is important, and how to implement reflection in educational settings. Many instructors know reflection can be used after instructional activities; but many are not aware that reflection can be used before and during the learning experience as well. Readers of this chapter can expect a practical guide on how to implement the reflection and reflective activities in their teaching.

Reflection Defined: What Is Reflection?

Reflection is a highly used instructional method in multiple content areas across different educational environments. Rooted in Dewey's (1991) beliefs, reflection is an active, ongoing, circular state where an individual considers their own beliefs, revisiting and revising those beliefs over time (Tracey et al., 2014). Reflection is a concept without an agreed definition. However, similarities exist across conceptualizations such as "the processes of reflection as involving the self, the outcome of reflection as a changed conceptual perspective" (Atkins & Murphy, 1993, p. 1189). Regardless of formal definition, reflection pushes individuals to turn back on an experience and "utilize their experience as a basis for assessing and revising existing theories of action to develop more effective action strategies" (Osterman, 1990, p. 133).

In the broad sense, reflection is accepted as an integral part of education and the learning experience for learners (Beauchamp, 2014; Tracey et al., 2014). As noted earlier, "Reflection is not a one-way, linear process; it is more comparable to alternating current, flowing back and forth between intense focusing on a particular form of experience and outer experience" (Boyd & Fales, 1983, p. 105). Types of reflection typically fall into two categories as defined by Schon (1983): reflection-in-action and reflection-on-action. Reflection-in-action happens when individuals have internal dialogues where they constantly identify and revisit a problem or experience as it occurs to the individual (a current, ongoing event). On the other hand, reflection-on-action looks at an experience, practice, or belief where individuals already constructed an idea or decision in their own minds (a past event).

Typically known as an individualized process, reflection must be considered "both an individual and a social process" (Noffke & Brennan, 2005, p. 74). Beauchamp (2014) notes in her review, "literature suggests a growing acceptance that reflection is not necessarily done in isolation" (p. 130). Learners have varying degrees of prior knowledge and since reflection asks them to individually look at their own learning, it is not surprising that the process of analyzing their own experiences, thinking, and actions would be highly independent (Tracey et al., 2014). However, individualization does not always mean isolation. While many researchers have found that reflection is a highly personal and individualized process (Beauchamp, 2014; Brookfield, 1987; Mezirow, 1990; Williams, 2001), reflection may also be completed with the input of other's views to help one look at their own learning (Beauchamp, 2014; Noffke & Brennan, 2005). This supports the idea that peers in a social learning environment create more meaningful learning experiences when working together (Jonassen & Reeves, 1996; Wang & Hsua, 2008).

Reflection As a Method: Why Use Reflection?

As briefly mentioned in the definition section, reflection is an integral part of education—but why (Beauchamp, 2014; Tracey et al., 2014)? In general, reflection allows a learner to process and apply new information both to themselves and to the larger community they are involved in (typically known as recall and elaboration) and to review and accept the decisions they made (personal assessment) (Boyd & Fales, 1983). In order to better understand reflection as an instructional method, two main educational environments will be examined: K-12 and higher education.

Reflection and K-12 Teacher Preparation

A major concern among American K-12 environments is the need for school reform (McCombs, 2003; Reigeluth & Karnopp, 2013; Smith & Larimer, 2004). As standardized testing continues to take a large seat in many American educational school systems, many researchers are calling for new ways in teaching practices and asking how “to prepare teachers to teach diverse learners” (Liu & Ball, 2019, p. 69). One potential answer to this call is later described in Liu & Ball’s (2019) work:

According to Mezirow (1990, 2000), attitudes and assumptions are important and subject to critical reflection; however, no matter how critical the reflection sounds or how great the apparent change in attitude, real change happens only with the transformation in actions—which we are referring to as “critical reflection for transformative learning.” (Liu & Ball, 2019, p. 88).

Dinkelman (1999) defines critical reflection as the “deliberation about wider social, historical, political, and cultural contexts of education, and deliberation about relationships between educational practice and the construction of a more equitable, [just], and democratic society” (p. 332). Therefore, reflection may be an instructional method to help prepare pre-service teachers because theories are useful to frame reflection processes which guide many teaching preparation programs.

Reflection and K-12 Environments

While reflection is a key component in developing teaching practices for pre-service teachers, it can also be used as an instructional method to help prepare K-12 students. In addition to pairing well with certain instructional methods, reflection could potentially help bridge the gap between what is being assessed and how students retain this information. For example, assessment (standardized testing) is typically viewed as a separate process from teaching and learning (Herman et al., 1992). Since this gap between assessment and teaching/learning already exists, a potential solution is creating situations where learners in K-12 environments can reflectively process the information they are learning in the classroom. Albert Bandura (1997) theorized that reflective processes can help learners acquire and retain information from different sources; therefore, reflection is equally important for students in teacher education programs and both K-12 students and teachers.

Reflection and Social Constructivism Theory

Although social constructivism theory is not new, the work of Lev Vygotsky and his zone of proximal development (ZPD) is a standard across all teacher preparation programs. According to Vygotsky (1978), “the ‘zone of proximal development’ is the level of development that the learner is capable of reaching under the guidance of teachers or in collaboration with peers. The learner is capable of solving problems and understanding material at this level that they are not capable of solving or understanding at their level of actual development; the level of potential development is the level at which learning takes place” (Vygotsky, 1978, p. 85).

The ZPD as described by Vygotsky suggests that social constructivism is meaningful learning that occurs when students are able to exchange ideas, negotiate meanings, and consult with their peers in a social learning environment (Jonassen & Reeves, 1996). Since many new teachers are already familiar with the ZPD, it can be paired with reflection as an instructional method to be used before, during, and after a topic has been introduced to students. During each point, the instructor can provide specific reflection questions to consider such as “What do you know about X?”, “What

did you learn about X after talking about it with your classmates?”, and “Now that you have learned about X, how does it apply to you?” By prompting students through reflection, they can think about and apply what they have learned or what they still want to learn about the topic covered in class.

Reflection and Higher Education

Higher educational experiences, for many college students, allow a safe space to consider and explore a range of topics. In many cases, learners are exploring new topics and concepts they have not yet heard or were exposed to in their previous education. The introduction of new information may be difficult to process; therefore, the role of reflection in learning new concepts allows students to think about what they are learning. Formenti and Jorio (2019) note critical thinking, self-reflexivity, and transformative learning are all crucial when teaching undergraduates (p. 209). Reflection, in an intentional and purposeful manner, can provide students the opportunity to engage in metacognition, often simplified as “thinking about thinking” (Miller et al., 1970, p. 613). In addition, Mezirow (1991) states reflection may lead to transformed schemas and perspectives within students. These new schemas can then help them retain and process new information. Therefore, instructors must consistently provide opportunities for learners to consider their own learning—both individually and in conversations with their peers (Formenti & Jorio, 2019).

In addition to learning and processing new information, many college majors stress the importance of reflection when training and preparing students to go into their respective fields (e.g. teacher preparation, nursing, healthcare, etc.). In these programs, Osterman (1990) found that “skilled practitioners are reflective practitioners” (p. 133) and that “practitioners step back and examine their actions and reasons for their actions” (p. 134). As mentioned earlier, Schon’s (1983) work describes two reflection practice categories: reflection-in-action and reflection-on action. By using reflection-in-action, students in a career preparation program are able to see “patterns of behavior become clear, habitual responses are identified and insights dawn regarding the nature of our assumptions and motivations” which help determine and justify why decisions were made by the individual (Brookfield, 1987, p. 78).

Reflection as an Instructional Method: How to Implement Reflection?

What Not to Do

In some situations, it is best to know what not to do before trying an instructional method in a classroom. Implementing reflection in any environment should be a meaningful experience and not fall into what Hunt (2013) states as “not just reflection on reflection” (p. 66). In order to create these experiences, one must plan for the implementation of reflection during the learning experience. As Watson & Kenney (2014) state, “Designing what the critical reflection exercise will “look” like, including how you [the instructor] will prompt students for reflection and how the reflection will be assessed, ought to be considered and planned” (p. 59).

First, we must note reflection should not be used if there is a lack of conscious, purposeful thought behind its design and implementation. One common critique of reflection is the lack of clarity and theory-practice gap when it is used (Beauchamp, 2015). The theory-practice gap is when teachers struggle to integrate knowledge learned in an academic environment (in this case, reflection) with real-world situations (e.g., why and how to correctly use reflection in their own classroom or teaching practices). This is because many reflections lack the necessary focus on the individual who is reflecting as well as including ethical-based questions that push the individual to consider questions such as “Is it right or just to accept this result/situation? What will be the best outcome? What is wrong here? Who does this hurt most? Why is this goal better than that one?” (Benade, 2012, p. 341). Along the same lines, reflection cannot occur without any conceptual understanding of what is being reflected on (Boud, 1999). Instructors must purposefully design and develop reflection based around a topic or skill being learned; “relabeling ‘free time’ in a course as reflection doesn’t achieve anything” (Boud, 1999, p. 125).

Second, reflections should not be so prescriptive that learners are essentially checking boxes. This type of reflection is known as "recipe following." As Boud (1999) states, "too often reflection is introduced to students as if it were a simple process of working through a series of prompts" (p. 125). This is a tricky task because reflections should not be left too open nor too prescriptive. One way to avoid this is by creating open ended questions that allow the learner to consider specific topics (typically what the instructor wants the students to learn) and how the learner can apply this new information in their own environment. Learners may be prompted to use writing for reflections, but should be allowed to express their thoughts in different varieties (discussions with peers or instructor(s), audio, video, project, etc.).

Third, the act of reflection should be considered a process and not a task. If viewed as a task or assignment by the instructor, students will view it the same. Atkins and Murphy (1993) states there is a process to this type of learning (see Figure 1). Since reflection is a process, it should be intertwined with teaching and learning, especially since "reflection is not an intuitive act, and must be taught" (Beauchamp, 2005, p. 134). Therefore, teaching students the necessary skills needed to be reflective individuals is crucial. Atkins and Murphy (1993) conducted a literature review and identified five skills needed for effective reflection practices: self-awareness, description (ability to recall key features of an experience or event), critical analysis, synthesis, and evaluation.

Figure 1

Reflection as a Process (Atkins & Murphy, 1993)



What to Do

Now that we are aware of potential pitfalls of using reflection, how can we effectively design and develop instruction to implement reflection successfully? Many studies have determined that if not implemented properly by instructors, reflection can become "mere gimmicks whose only potential is further, unnecessary validation of Seymour Sarason's (1971) axiom that the more things change, the more they stay the same" (Kottkamp, 1990, p. 182). Therefore it is important that as instructors, we must first understand and consider a mind-set change if we fall into the category that reflection is a task. As noted by Beauchamp (2005), "We need to shift our focus from it [reflection] as a required tool in programs...and explore more fully its meaning and potential for enhancing professional practice" (p. 137).

Second, we must prepare and develop skills for reflective practice in our learners so that they can effectively reflect on their learning. Tied with the development of the necessary skills mentioned before, we must also explain and teach our learners about what reflection is, why we are using it, and the value it has in their learning. Obviously, for younger learners, this may be a bit more difficult to do. One way to help involve younger students in the reflection process is to have open ended sentences that they complete at the end of an activity (e.g., "Today I learned about ____"). These types of activities fall into what Zhang et al. (2004) label as reflective support that "prompts their reflective abstraction and integration of their discoveries" (Zhang et al., 2004, p. 270). In addition, the idea of game-based, video-based, or discussion-based reflection activities or projects may also gain younger learners' attention. Younger learner's parents or caretakers could also be involved in reflection activities, having students do mini-reflective projects or assignments while at home (e.g., more extensive questioning such as "What did you learn at school today?", "How does that apply to X?", and "Why do you think topic X is important?").

Lastly, and possibly the most difficult, is to develop reflective opportunities that are meaningful (not superficial) but not so restrictive where learners view it as checking off boxes. One way to tailor questions for learners is to create a

question bank related to “social, political, and moral issues as well as prompts to draw connections between course readings and student experiences” (Tracey et al., 2014, p. 318). Since the backgrounds of students vary, it is difficult to give a bank of questions for instructors to use. This piece of the puzzle will rely heavily on the instructor knowing their students and providing guiding questions based on their learners’ circumstances, upbringings, socioeconomic status, prior knowledge, etc. One example could be if a student is interested in video games, the instructor could ask how a specific physics law plays a role when developing video games. Another example could be how mathematical calculations determine a player’s statistics in sports (e.g. baseball, basketball, soccer).

Reflective Practices

As noted above, specific examples of reflection in practice are truly dependent on the topics and what you want your learners to take away from a lesson or experience. As such, Table 1 lists out different types of reflection activities, a general description, a sample illustration, and technology tools that can assist in its implementation. Figure 2 is a list of reflection question prompts.

Table 1

Application of Reflection Activities

Reflection Activity	Description	Illustration in Practice	Technologies
Reflective Journal or Blog	A record of a particular subject, experience, or professional activity.	<p>After reading an assigned document, students are prompted to recall and write how they felt, what they learned, or any lingering/remaining questions.</p> <p>In younger populations, this can be prompted by open-ended questions where learners answer a question (e.g. “Today I learned about ____”).</p>	<p>Pen and paper</p> <p>Worksheets</p> <p>Electronic journals or blogs</p> <ul style="list-style-type: none"> • Wix • Weebly • Padlet
Log Book	Similar to reflective journals or blogs, a log book is typically used in science environments to document specific steps or experiments and the outcomes of those activities.	While conducting an experiment, learners will take notes during each step of the process (goal of the experiment, why they are conducting the experiment, what they predict will happen, what does happen, etc.). Additionally, specific notes of changes during the process should be made to determine if any changes affected the outcome of the experiment.	<p>Pen and paper</p> <p>Electronic journals or blogs</p> <ul style="list-style-type: none"> • Wix • Weebly • Padlet <p>In an online virtual lab, this may be embedded into the activities or steps learners complete.</p>

Reflection Activity	Description	Illustration in Practice	Technologies
Micro-Blogging	Typically associated with social media, micro-blogging is the practice of making short, frequent posts to a microblog. This form of reflection is typically more social and informal.	After experiencing an event, an individual writes a quick, short note via social media in regards to that experience.	Social media <ul style="list-style-type: none"> • Facebook • Twitter • LinkedIn
Wikis	Collaborative online pages, wikis, allow users to edit information in real time with any individual with access. Wikis are typically used in social, collaborative environments as any user can edit information at any point.	A wiki page is created on a topic of interest to a person or group. As information is gathered regarding that topic, all members are able to edit, add, and remove information from the wiki. The final result is a collaborative document with information from different sources (individuals).	<ul style="list-style-type: none"> • Wikispaces • Google Doc • Learning Management Systems (LMS) • OneDrive
Group Reflection	As mentioned in the literature, reflection is not typically done alone. Group reflection refers to conversations between peers where particular subjects, experiences, or professional activities are shared among the group.	<p>After experiencing an event, individuals collaboratively reflect and discuss feelings or emotions, new knowledge, or any lingering/remaining questions in regards to the shared experience.</p> <p>Assemblage of individuals for group reflection can be done in a number of ways: 1) whole class, 2) by skill or ability, 3) shared experiences, etc.</p>	Padlet VoiceThread Skype Google Hangouts Zoom WebEx
Video Reflection	Rather than writing, some individuals are able to communicate and explore their thoughts better using the practice of video reflection. Video reflection is a video recording of a specific subject, experience, or professional activity. Video reflection is particularly useful in online classroom environments to help build community between learners at a distance.	<p>After each week or module, individuals can reflect and discuss feelings or emotions, new knowledge, or any lingering/remaining questions in regards to the topic they learned. At the end of the course, learners can go back and watch their previously-recorded videos to see their growth over a certain amount of time.</p> <p>In some cases, seeing rather than reading may be more effective.</p>	Computer webcam Cell phone camera Video recorder Padlet VoiceThread Flipgrid Skype Google Hangouts
Audio Reflection	Much like video reflection, some individuals are able to communicate and explore their thoughts using their voice alone. Audio reflection is an audio record of a particular subject, experience,	In lab type courses (especially in medicine education), audio reflection allows the individual to capture thoughts and notes while working. Specific examples of this are talking during an autopsy to note things of interest, or to review later, or	Computer microphone Cell phone microphone Tape (voice) recorder Padlet

Reflection Activity	Description	Illustration in Practice	Technologies
	or professional activity. Audio reflection is particularly useful in online classroom environments to help build community between learners at a distance.	taking audio notes during a surgery to recall steps taken in a process.	VoiceThread Flipgrid Skype Google Hangouts
Multimedia Reflection	Multimedia refers to having multiple mediums (text, video, image, audio, animation, etc.) at one's disposal while reflecting on a particular subject, experience, or professional activity.	Some learners are able to associate information they learned in different styles and formats; as such, learners should be able to reflect in similar ways. Rather than limit learners to use one medium for reflection, open the requirements up and allow learners to use multiple media.	Text (typed or written) Microphone (cell phone or computer) Camera (cell phone, computer, etc.) Padlet VoiceThread Flipgrid
Peer Review & Revision	Peer review is a process where individuals review, critique, and assess another's work for summative or formative purposes. When combined with scaffolds, peer reviews allow learners to consider refining their own work during the revision process based on notes from their peers.	In many cases, peer reviews allow for reflection twofold. First, by reviewing work of others, an individual is able to review and see what they would do both differently and similarly to the document they are reviewing. Second, by continuing to receive feedback from peers, an individual is able to identify both areas of weakness and strengths within their own work.	Pen and paper Annotations in Word or Google Docs Video or voice reflection
Exit Slip or One-Minute Paper	Exit slips are informal assessments given to students (typically at the end of a course) to consider a question posed by the instructor. Similar to the exit slip, a one-minute paper is when students are given one minute to write as much as they know about a topic (either before or after the topic is taught).	Exit slips are considered low-stakes and allow the learner to recall and activate prior knowledge. Before discussing or introducing a new module, a teacher may ask students to define or explain a new concept. At the end of a class, a teacher may ask students to write as much as they can on a topic that they learned that day or the day before using a one-minute paper.	Pen and paper Electronic quizzing tools <ul style="list-style-type: none"> • KaHoot! • Quizzz • QuizMaker Electronic survey (open ended question) <ul style="list-style-type: none"> • Qualtrics • SurveyMonkey
Portfolio	A portfolio is a compilation of materials that highlights a person's beliefs, skills, qualifications,	In order to enter the job market, career preparation students create a professional portfolio in order to demonstrate projects	Portfolios can either be paper based or electronic

Reflection Activity	Description	Illustration in Practice	Technologies
	education, training, experiences, etc. Portfolios require reflecting on particular elements to demonstrate competency.	they have developed and competencies they have mastered. Portfolios for some careers are used as part of the interview process for positions after schooling.	<ul style="list-style-type: none"> • Binder and papers • Wix • Weebly • Portfolium • TaskStream (teacher education) • Portfoliobox • Crevado

Figure 2

Reflection Question Prompts

HERE ARE A FEW OF OUR FAVORITE REFLECTION QUESTIONS TO USE IN YOUR INSTRUCTION. ADJUST OR EDIT THESE QUESTIONS TO MEET YOUR STUDENTS' NEEDS.

BEFORE STUDENTS BEGIN THEIR WORK:

- What do I know about this topic or subject?
- What would I like to learn about this topic or subject?
- Where will I find the information I need for this assignment?
- What kinds of research do I need to do?
- Do I fully understand the question or prompt?
- How can I break down the assignment into smaller parts?
- Did I give myself ample time to really think about this assignment and brainstorm possible solutions?
- Who can help me get what I need to complete this work?
- What tools or supplies should I use for this assignment?
- How will I be assessed for this project?
- Do I understand all parts of the rubric or scoring guide?
- What are my goals for this assignment?
- What do I need to do in order to meet those goals?
- How will this assignment be turned in to my teacher?
- Do I know the due date for this project, and am I able to meet it?

WHILE STUDENTS ARE WORKING:

- What have I learned so far?
- What else do I need to know in order to finish this task?
- Can I make a few predictions about what will happen next?
- How well am I using my time?
- Am I answering all parts of the questions completely?
- Which parts of this assignment are easy for me?
- Which parts of this assignment are challenging for me?
- Does my work reflect my effort thus far?
- Am I putting forth my best effort in my work?
- Are the sources I am using valid and reliable?
- Am I citing my sources properly?
- How close am I to achieving my original goals with this assignment?
- Are the goals I set before I began this assignment still reasonable? Do I need to readjust them?
- If possible, can I ask my teacher or a classmate for feedback on my current progress on this assignment?
- Am I learning interesting information as I work on this project?

AFTER STUDENTS FINISH THEIR WORK OR ASSIGNMENT:

- What new information have I learned from this assignment?
- What surprised me about what I learned?
- How quickly was I able to finish this work?
- Where were my roadblocks?
- How did I move through roadblocks or challenges?
- Is my work adapted for the correct, appropriate audience?
- How closely did I follow the parameters of the assignment?
- Using the grade rubric, how would I score my own work?
- What would the teacher say about my work?
- If given the opportunity, one thing I would change about this assignment is . . .
- How does my work compare to what my classmates did on this assignment?
- Does my work truly reflect my effort?
- Have I achieved the goal I set for myself with this assignment?
- What would I do differently next time, if given the chance?
- Am I proud of my work?

WE ARE TEACHERS

Note. Retrieved from <https://edtechbooks.org/-KVmN>

Conclusion

This chapter focused on the use of reflection as an instructional method for teaching and learning. The main takeaways from this chapter are to use reflection effectively and not to use reflection for the sake of using it. This chapter first addressed what reflection is and how it is defined. Next, it covered elements of why reflection should be used as an instructional method. Lastly, this chapter presented how to use reflection by listing different reflection activities, an

example in practice, and different technologies that could be used when implementing reflection. While examples of reflection in practice are given, instructors must understand, plan, and prepare questions to elicit in-depth responses considering individual concerns and beliefs regarding a particular subject, experience, or professional activity.

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Role-Play

Arpit Bawa

In this chapter I will examine the concept of role-play, and its efficacy as an instructional method. This chapter first introduces the role-play and its major components, then the significance of role-play in education, and suggestions for implementation of role-play.

Defining Role-Play

The Merriam-Webster dictionary (2019) has several definitions for the word 'role-play,' such as "to act out the role off," "to represent in action," and "to play a role". In education, several studies have had varying but similar definitions of role-play, ranging from calling it an experience to referring to it as a pedagogy (Agboola Sogunro, 2004; Hidayati & Pardjono, 2018; Radford & Stevens, 1988; Rao & Stupans, 2012; Westrup & Planader, 2013). Using the common themes between these definitions as a reference, role-play is defined in this chapter, as an instructional method where learners take on the responsibility of representing different character roles, within predefined, often realistic, scenarios

Components of Role-Play

A different approach to understanding role-play, is to examine the vocation of acting. Actors are required to act out scripts that contain lines representing characters in the story. Here we know it is the actor's responsibility to accurately convey the feelings and actions of the characters they are representing, but they must be guided by the director and the script. Can you imagine a movie or play that had random lines for the actors, with no connection or context between them? Much like acting, role-playing must include roles that learners can represent and a scenario that defines the context for the actions that role-players must take. Now you may find yourself asking, but what about the directors' influence?

The director is responsible for guiding and directing the actors to better connect with their roles. Similarly, role-play in education requires a guide or facilitator to work with the learners. A study conducted by Cobo et al. (2011) revealed that the addition of a guide or facilitator was necessary to maximize the benefits received from a role-play session. Another study using role-play discovered the importance of having mentors provide guidance to students during and after their role-play sessions (Nakamura et al., 2011). Taking these revelations and combining them with our definition for role-play, there are three major components needed to successfully implement role-playing: scenarios, roles/characters, and guides/facilitators.

Scenario

Continuing our movie example, the actors need to have a script that they can follow to better understand how to represent their characters. Similarly, role-play scenarios need to include relevant background information that will help establish the limitations, motivations, and the problems that learners will need to solve (Radford & Stevens, 1988). The problem should align with the content provided and be ill-structured to give students the flexibility to engage in critical thinking. For example, if the objective of the lesson is to teach manufacturing, then the theme of the scenario should relate to manufacturing, the roles/characters should be based around employees in manufacturing factories, and the

problems, presented in the scenario, should relate to the theme. In terms of structure, the scenario should be detailed in areas that help define roles, context, and problems, but remain open ended about actions that can be taken by the roles/characters. This will give the learners a chance to dictate what actions need to be taken.

Roles/Characters

Much like scenarios, roles or characters need to be well defined, taking into consideration their expertise and limitations (Rao & Stupans, 2012). The roles should be based on the theme of the scenario and should be connected to the problems presented for the role-play session. For example, simply giving the learner a role of 'manager', will not be enough. The learner will need to know what the expertise of the manager is, what strategies they tend to use, and what position they hold in the company. Not knowing these parameters and limitations will reduce the effectiveness of the role-play, as learners will be able to give solutions that are outside the scope and expertise of the role they are representing. Additionally, if there is more than one role, then it is important to define the connection and relationship between the different roles. For example, the manner and method of communication between managers will be different than between a manager and an employee—making it important to define what the responsibility of each role is. Just imagine the chaos that would ensue if all movies were based on impromptu acting and had no defined roles for the actors.

Guides/Facilitators

If actors and scripts were enough for a movie to be successful, then there would be no demand for directors. The guides or facilitators in role-play sessions, have a similar role in providing direction to the learners. However, simply assigning an instructor to be a guide is not enough. To be effective, the guides or facilitators must prepare for the sessions in advance and have expertise on the relevant subject matters covered in the role-play sessions in order to answer player questions (Cobo et al., 2011; Radford & Stevens, 1988).

Significance of Using Role-Play in Education

Now that we have discussed what role-play is, let us see what value role-play has as an instructional method. Specifically, we are going to be looking at how role-play promotes active learning, positive player-to-player and player-to-instructor interaction, and increased student engagement and motivation. These elements provide significant value to the efficacy of using role-play in education.

Active Learning Approach

Role-play is considered as a possible method for achieving active learning (e.g., Bonwell & Eisen, 1991; Westrup & Planader, 2013). The active learning approach has been defined in several studies, across subject matters, as an approach that actively involves learners in their own learning process, letting the instructors act as guides and providing learners with opportunities to grow (Ghilhay & Ghilay, 2015; Graaf et al., 2005; Pekdoğan & Kanak, 2016). As learners engage in critical thinking—through representing characters and making decisions on how to advance through the scenario—they actively engage in their learning process. Also, putting the responsibility of learning in the hands of the learners provides them with more control over their own learning process. This kind of student-centric approach also leads to higher student engagement and participation (Bonwell and Eisen, 1991; Howell, 1992).

Increased Learner Engagement and Motivation

One of the main goals for any instructional method is to improve the effectiveness of instruction, leading to higher student performance and satisfaction. Cobo et al.'s (2011) research revealed that using role-play, in engineering studies, had a positive impact on learner engagement and motivation. They noted that the students were answering emails even outside of designated class time, which was contrasted with the authors' previous experiences that showed decrease in student engagement outside of class. In another study Agboola (2004) discovered that after applying role-play in education leadership courses, students showed increased interest in students, which led to an increase in their

understanding of the content of the course. Both studies indicate that role-play has a positive correlation between its use and an increase in student engagement and motivation across subject matters.

Increased Interaction Between Learners

Another important aspect involved in role-play is the interactions between the learners and the instructors. The interactions can take place as discussions, debates or even casual conversations, allowing the learners to observe each other during the session. This level of interaction helps develop a sense of community between the learners in the session and provide opportunities to practice communicating in various social contexts (Ladousse, 1987). Role-play interaction also aligns with Bandura's (1977) social learning theory, whereby learners increase their motivation towards actions they observe other learners making.

Considerations

Before we talk about implementation, it is important to keep some things in mind when considering role-play as an instructional method. These considerations include the amount of time required for role-play sessions, management of the level of complexity of the problem and scenario, and the increased workload for the facilitators. It is imperative to plan for these considerations before initiating role-play.

Time Requirement

One scenario for role-play has the potential to last for several weeks, depending on how many problems are introduced, or how much time is allotted for each session. Learners can also take several sessions to acclimate to the idea of role-playing their characters (Radford & Stevens, 1988). Extra care must be taken in determining how much time is available when considering using role-play in classrooms.

Level of Complexity

The open-ended nature of role-play allows each session and scenario to be tailored to the needs of different demographics of learners, regardless of age or expertise in role-playing. However, it is important to recognize the difference between children, adults, novice, and expert learners when it comes to the level of complexity they can handle. For example, a study by Radford and Stevens (1988) revealed that undergraduate students new to role-play had difficulty participating in the sessions but got more comfortable over the next few sessions. A study by Nakamura et al. (2011) showed that novice learners tended to 'stick to the script', and not deviate or explore during the sessions. This was a problem as the script was only meant to guide the learners, and exploration was required to fully engage with the content. This prompted them to introduce experts, to facilitate the session, for each group. The experts were able to provide opportunities for the learners to deviate and explore the scenario, which maximized the effectiveness of each session. Taking this into account it is important to recognize the demographic of the learners that will be participating and designing the role-play sessions, with appropriate complexity to match them. For example, novice audiences will require more scaffolding and guidance, when compared to learners who have experience in role-playing.

Increased Workload for Instructors/Facilitators

Role-play sessions tend to increase the workload for the facilitators and are difficult to prepare for and conduct (Nakamura et al., 2011; Radford & Stevens, 1988). The higher the player count, the more difficult it is to facilitate the session. The nature of role-play also requires the facilitators to respond to prompts quickly, as learners run the risk of being waylaid or stuck during the session, lowering its effectiveness (Nakamura et al., 2011). Implementing role-play successfully will require instructors to be thorough with their preparation, and account for the increase in student questions. Instructors may also need to seek assistance with facilitating the sessions.

Implementing Role-Play: How to Use Role-Play for Learning

To create a successful role-play session, it is important to establish the problem you want learners to solve, the theme for the scenario that best fits the problem, and the total time you want to allocate to the session. Determining these factors will provide a solid foundation for creating the session. The time limit will gauge the level of complexity that the problem can have, while keeping the theme and problem connected will make it easier to create roles/characters that fit. The last step will be implementation, where the session will need to be in a location that has enough room for the participants to be close enough to comfortably communicate with each other and the instructor. The checklist created by Howell (1992) provides more details on how to set up and prepare for a role play session. Two examples, one for corporate education and one for higher education, on implementing role-play have been provided below.

Worked Example: Training to Teach Safety in the Workplace

Below is an example of the steps to take to implement a role-play session for a training to teach workplace safety:

1. Problem. Determine what the underlying problem is. What are you trying to train? In this case it will be about workplace safety.
2. Scenario. Include details about the internal and external workplace environment, location, culture, roles/characters, and other relevant information. For this situation, be sure to include current safety policies, any issues associated with them, their effectiveness/importance, and other additional safety measures that you want your learners to know. Common safety policies include having emergency safety equipment—such as fire retardant on hand—and ensuring there is always adequate ventilation and heating in the workplace.
3. Roles/Characters. Provide details that include motivation, job title, expertise and limitations. Be sure to connect the roles to the theme, problem, and to each other. The main characters here should be employees, managers, and human resources representatives. An example description of an employee can be Jill, who has been working in this company for 4 years. She is well liked and receives good reviews from her supervisor. Jill has complained in the past that some of the policies are confusing and difficult to remember.
4. Total time. Determine the maximum time allotted per session. Adjust the problem, lowering or increasing complexity, depending on available time. Time limit will be determined by company policy, and the time allowed for professional development. An average good time might be 2 hours a week, per session, for a month.
5. Provide materials, such as the scenario and relevant subject matter information, to the learners. Make sure all learners understand the concept of role-playing, are aware of the scenario, and the roles assigned to them at the start of each session. In this case, learners should be assigned the roles of employees and manager. The role of human resource representative should go to the facilitator of the training.
6. Location. Select an appropriately sized location that can hold participants and other observers. The participants must be allowed to comfortably communicate with each other. In this case you can use a large conference room or an outside location that can host the required number of stakeholders.

Worked Example: Teaching Marketing Principles Using Role-Play

Below is an example of the steps to take to implement a role-play session teaching marketing principles:

1. Problem. Determine what the underlying problem is. What are you trying to teach? What are the objectives of the lesson? In this case, it will be about teaching marketing principles, which can include topics such as the 4 Ps of marketing or target audience analysis.
2. Scenario. Include details about the environment, background for the characters, location, culture, details about the roles/characters, and other relevant information. For this example, the focus should be on creating a relatable background such as a new marketing project being started in a business. Details, such as the name of the business, the location, work culture, and product lines, should be provided.
3. Roles/Characters. Provide details that include motivation, job title, expertise and limitations. Be sure to connect the roles to the theme, problem, and to each other. The main characters here should be marketing employees, manager(s), and team leader(s). A possible description for marketing employee could be Mark, who has 3 years of working experience in marketing, and he specializes in target market analysis. He is a hard worker, gets good reviews, and aspires to lead his own team for marketing projects. Unfortunately, Mark has trouble communicating with his peers, and often has difficulty articulating his ideas.
4. Total time. Determine the maximum time allotted per session. Adjust the problem, lowering or increasing complexity, depending on available time. Time limit will be determined by the total course time, time allotted in the course for assignments, and the frequency of the sessions, per week. An average good time might be one session a week for 50 minutes.
5. Materials. Provide materials such as the scenario and relevant subject matter information to students and assign roles. Make sure all students understand the concept of role-playing, and are aware of the scenario and the roles assigned to them at the start of each session. In this case, students should be assigned the roles of marketing employees, with the instructor being assigned team leader or manager.
6. Location. Select an appropriately sized location that can hold participants and other observers. The participants must be allowed to comfortably communicate with each other. In this case, a classroom setting will work. However, depending on the number of students, the seating structure of the classroom may need to be adjusted.

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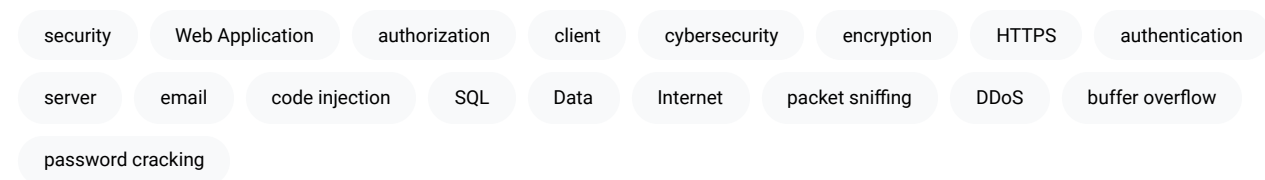


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Secure Web Application Development

Nathan Fox



Beginning web application developers have a tendency to focus so strongly on getting an application to work correctly that they forget one critical component of development—security. To effectively protect a web application, developers have to think like hackers and have to know what kinds of attacks to expect, which is difficult for beginning developers who lack experience with hackers. Hackers can exploit security vulnerabilities to access or delete user data, to break the application’s functionality, to prevent legitimate users from accessing the application, or even to gain control of the servers the application is running on.

Security is a big issue in the professional world, and even professionals make mistakes. Consider these security breaches that made headlines:

- In December 2013, hackers accessed credit card data for 40 million Target shoppers, leading to over 90 lawsuits and a noticeable decline in Target’s sales (Riley, Elgin, Lawrence, & Matlack, 2014).
- In an attack on Home Depot’s systems nearly a year later, 56 million credit card numbers and email addresses were compromised (Banjo, 2014).
- A well-orchestrated attack on Code Spaces, an application where users could collaboratively write source code, forced the company out of business when the attackers wiped its databases (Code Spaces, 2014).

Developers must understand how to secure their web applications if they want to protect their users, data, and servers. This chapter discusses common attacks that hackers use and what developers can do to defend against them.

What is a Web Application?

Before learning about web application security, it is important to know exactly what defines a web application. A web application is a program that runs on computers called servers that the application developer either owns or rents. Those who use web applications interact with them from computer programs called clients. There may be multiple clients, each with a different interface, for a single web application. For example, Twitter is a single application that can be run in a desktop browser, a mobile browser, an iPhone app, or an Android app. Each Twitter client has a slightly different user interface, but each interacts with the same Twitter application by connecting to Twitter’s servers. Clients interact with servers by making requests to get, create, update, or delete data. Servers listen to the clients’ requests, run the application to fulfill those requests, and then send appropriate responses to the clients.

Protecting Web Applications from Common Attacks

Beginning developers frequently do not know how to defend their web applications, because they are unfamiliar with methods that hackers use to attack. Hackers use a variety of attacks in an effort to access sensitive user data. If developers want to know how to effectively prevent attacks to keep data secure, they must be familiar with attacks that hackers might use against their applications. Common attacks include (but are not limited to) packet sniffing, bypassing authorization rules, password cracking, code injection, distributed denial-of service attacks, and buffer overflow attacks. The following sections will describe how these attacks work and how developers can defend their applications from these attacks.

Packet Sniffing

The internet works by sending electromagnetic signals through wires, fiber optic cables, and the air. These signals represent the data sent between machines and are separated into small groups of data known as packets. Packet sniffing occurs when the attacker uses a wire tap or a radio receiver to record packets that are in transit. All packets sent over the internet are vulnerable to packet sniffing. The only way to protect sensitive data is to encode the data in such a way that only the intended recipient can decode it. In other words, data must be encrypted while in transit in order to be secure.

The HTTPS protocol. Fortunately, application developers are not expected to write code to encrypt data. There is an existing internet protocol that performs encryption and decryption operations: HTTPS. HTTPS uses a secure method (known as a handshake) to establish encryption and decryption keys between the server and the client. By enabling the HTTPS protocol on an application's web servers, the developer can ensure that all web traffic between the server and the client will be encrypted. If any packets are recorded by packet sniffers, the encrypted data will be indecipherable. The process of enabling HTTPS is different for every server, so developers will need to refer to their server's documentation for specific instructions. Though enabling HTTPS may seem like a hassle for a beginning developer, it is necessary to secure any sensitive information that flows between users and the application servers.

Email. If a web application communicates with users by sending emails, the developer must be careful to not include any sensitive information in those emails. Most email protocols (e.g., POP3, IMAP, SMTP, HTTP) do not encrypt data that is in transit. As a general rule, expect email to not be secure (Duncan, 2013). If a web application needs to communicate sensitive information to a user, the application should send a generic email prompting the user to log into the application and then display the sensitive information to the user once the user logs in.

Bypassing Authorization Rules

The process of logging into an application is also known as authentication. A user provides authentication tokens—typically a username and password—to the application, and the application confirms that the tokens are authentic. Once a user's identity is confirmed, the application uses authorization rules to decide what data the user is allowed to access and what actions the user is allowed to perform. For example, a standard user may be authorized to write comments, view personal comments, and view comments written by friends. An administrative user, on the other hand, may be authorized to view, modify, or delete any comments.

A common mistake that beginning developers make is to use client-side code to enforce authorization rules. Client-side code is code that is executed on the user's device. For a web application, client-side code is typically HTML and JavaScript, and it is executed in the user's web browser. In the previous example, the HTML for an administrative user may include a delete button to delete comments, though the delete button would be hidden for standard users. Displaying only HTML elements that the user is authorized to use is a good design practice, but it is not sufficient for enforcing authorization rules. Because client-side code is executed on the user's device, there is no guarantee that the client will execute the code in the way the developer intended. Even if a standard user cannot see the delete button, it is still possible for the user to bypass the authorization rules built into the client-side code and submit a delete request directly to the application's servers. Thus, authorization rules cannot be enforced in client-side code alone but must always be enforced in server-side code.

Server-side code is code that is executed on the application's servers. Common server-side programming languages include Java, ASP.NET, PHP, Python, Ruby, and Node.js. Server-side code acts as an intermediary between the client and the data, so data will not be secure if the server-side code fails to protect it. Whenever a user makes a request to one of the application's servers, the server should verify that the user is authorized to perform the request. If the user is not authorized, the server should respond with an error message and terminate the request. Then, even if a user is able to circumvent any client-side defenses, the server will enforce the authorization rules to help keep the data secure.

Password Cracking

If attackers cannot find a way to bypass authorization rules, they may try to guess or steal the authentication tokens of other users. Although users are primarily responsible for securing their own passwords, there are ways for application developers to help protect user passwords:

- Never send a password in an email or over a connection that is not using the HTTPS protocol. Only exchange passwords over encrypted connections to protect passwords from packet sniffing.
- Never store raw passwords. Instead, use a cryptographic hash function (such as a SHA-2 algorithm) on a password to get a digest, then store the digest. When a user provides a username and password, run the same hash function on the given password and compare that digest to the stored digest to authenticate. If an attacker manages to steal the application's password digests, it will still be very difficult for the attacker to recover the original passwords.
- Enforce a cap on how many times a user is allowed to attempt to log in with a wrong password. Attackers may try to use computer programs to submit thousands of authentication attempts in just a few seconds. If a single user fails to provide a correct password after several attempts, the application should not allow the user to try to authenticate again for a period of time. This prevents an attacker from trying millions of guesses until the correct password is found.

By helping users secure their passwords, application developers can reduce the likelihood of successful attacks and keep sensitive user data from getting into the wrong hands.

Code Injection

If a web application stores user input in a database or shares one user's input with other users, then the application is potentially vulnerable to an attack known as code injection. Code injection occurs when a user submits code in an input field, and the application unwittingly uses that input in such a way that any code in the input might be executed. The executed code could potentially allow the user to delete the entire database, download sensitive data, or break the web application's functionality. To effectively protect web applications, developers must defend against two common code injection attacks: SQL injection and cross-site scripting.

SQL injection. SQL is a querying language that developers use to interact with relational databases. Hackers may try to use SQL injection to make unauthorized changes to a web application's database. Fig. 1 illustrates an example in which the developer uses PHP as the server-side programming language and SQL as the database language. The developer builds an insert statement (a line of SQL code used to add new data to a database) and places the user's comment into the insert statement. If the user submits a typical comment (e.g., "I had a great time at the lake today!"), then the comment will be successfully saved in the database. However, a hacker may try to attack the database by trying to submit SQL code as a user comment. For example, if the user submits `"test", `hacker123`, now()); DROP TABLE user_comments;--"` as a comment, then all user comments will be deleted from the database, and the developer will be left with nothing but a group of angry users.

Figure 1

An Example of How a Hacker Might Use SQL Injection to Make Unauthorized Changes to Data

```

$username = $_SESSION['username']; // Get username for current user
$userComment = $_POST['userComment']; // Get user comment from browser input

$sqlStatement = "INSERT INTO user_comments
                (comment_text, author, created_date_time)
                VALUES (`$userComment`, `$username`, now())";

/* If user comment is "I had a great time at the lake today!"
 * then the comment is successfully saved in the database */
$sqlStatement = "INSERT INTO user_comments
                (comment_text, author, created_date_time)
                VALUES (`I had a great time at the lake today!`, `bob123`, now())";

/* If user comment is "test`, `hacker123`, now()); DROP TABLE user_comments;--"
 * then all user comments will be deleted */
$sqlStatement = "INSERT INTO user_comments
                (comment_text, author, created_date_time)
                VALUES (`test`, `hacker123`, now()); DROP TABLE user_comments;--`, `bob123`, now())";

```

For a web application that needs to save user input into a relational database, the developer must protect against SQL injection to keep the data safe. Developers can use code libraries (such as PHP's PDO library) that can prepare SQL statements in a safe way by removing parts of user input that may be unsafe to execute (cf. Fig. 2). For databases that do not use SQL (e.g., MongoDB, Cassandra, Redis), there are still vulnerabilities to code injection attacks. To effectively defend web applications that use NoSQL databases, developers must research vulnerabilities and learn about recommended precautions to take.

Figure 2

An Example of How a Developer Can Use Prepared Statements to Prevent SQL Injection

```

$sqlStatement = $connection->prepare("INSERT INTO user_comments
                (comment_text, author, created_date_time)
                VALUES (?, ?, now())"); // Use ? in place of input parameters
$input = array($userComment, $username);
$success = $sqlStatement->execute($input); // Sanitize and execute the query

```

Cross-site scripting. Web applications that save input from one user and display it to other users are potentially vulnerable to cross-site scripting attacks, also known as XSS attacks or JavaScript injection. To attempt a cross-site scripting attack, a hacker submits HTML and JavaScript code as user input. The hacker hopes that when the web application displays the comment to other users, the other users' browsers will render the HTML and execute the JavaScript. Hackers can potentially use cross-site scripting to steal sensitive data from other users, to open pop-ups or iframes to other websites, or to download malicious software onto other users' devices. There are two common methods used to protect web applications from cross-site scripting attacks: stripping HTML tags and whitelisting HTML tags.

Stripping HTML tags from user input is a relatively simple method to implement. A web application sanitizes user input by removing all HTML tags (defined by text between the < symbol and the > symbol) from the input, then stores the sanitized input in the database. When the web application retrieves that data from the database and displays it to another user, the lack of HTML tags will allow the other user's client to display the input text without executing any code.

The main limitation of stripping away all HTML tags is that the developer may want to allow the user to input certain HTML tags—such as hyperlinks, lists, tables, or formatting tags—to make the application more flexible and user-friendly. Whitelisting HTML tags is done by enumerating a list of acceptable tags and removing all other tags from user input. This method may be difficult to implement for beginning developers, but many programming languages have libraries (such as the OWASP HTML sanitizer) that implement whitelisting functions that are relatively simple for developers to use. Due to the complexity of whitelisting functions, beginning developers may want to look for available sources before attempting to write these functions on their own.

Distributed Denial-of-Service

To execute a distributed denial-of-service (DDoS) attack, a hacker programs multiple devices (or bots) to flood a web application's servers with requests. The application servers utilize all of their resources to respond to the hacker's flood of requests, making it difficult for legitimate users to get any data from the application server. Servers may eventually be driven into a state of deadlock and crash. Because the hacker uses multiple bots with unique MAC addresses and IP addresses, it is difficult for the application servers to distinguish between the hacker's requests and legitimate requests. If a web application falls prey to a distributed denial-of-service attack, the developer can purchase third-party DDoS mitigation software that thoroughly analyzes incoming traffic in an attempt to distinguish bot requests from legitimate user requests.

Buffer Overflow

A buffer overflow attack (also known as a stack smashing or stack overflow attack) is an attack that is very difficult for hackers to execute, as it generally requires a lot of guessing and a lot of luck. The goal of a buffer overflow attack is to hack into the operating system of one of the web application's servers. The attack is executed by injecting binary—also known as bytecode or machine code—into the web application's run-time stack. The run-time stack is part of the server's RAM (memory) that is allocated to store temporary data, including flow control data, for the web application. The hacker tries to overwrite part of the run-time stack with executable bytecode, then overwrite the stack's flow control data to make the application execute the injected bytecode. If a hacker executes the attack correctly, the hacker may gain access to all data stored on the application's servers: usernames and passwords, source code, database credentials, etc. Since this attack targets the server's operating system, keeping the operating system up-to-date is an important part of preventing a buffer overflow attack. It is also important to keep code libraries and compilers up-to-date (Frykholm, 2000).

Conclusion

Protecting a web application is not simple, but it can be critical to the application's success. Hackers use a wide variety of attacks to access sensitive data, and it is important for developers to understand how those attacks work and how to effectively defend against them. By taking time during the initial development phase to learn about and implement security features, web application developers will save their time, their money, their customers, and their data in the long run.

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Socratic Seminar

Daniela Castellanos-Reyes

This chapter will discuss the Socratic Seminar as an instructional method, its historical roots, definitions, uses, and practical considerations. Readers can use this chapter as a practical guide on how to implement the Socratic Seminar in their teaching. A table and infographic (see Figure 2) are provided at the end for practitioners to guide their Socratic questioning.

What Is the Socratic Seminar?

The Socratic Seminar, also known as Socratic Dialogue, is rooted in the conversations the Greek philosopher Socrates (470–399 BC) had with his pupils (Schneider, 2013). Socrates, known as an excellent teacher, established dynamic conversations with his learners, empowering them to construct their understanding of complex matters, and think critically about evidence (Chowning, 2009). The Socratic Seminar has no single definition (Acim, 2018). From a teaching perspective, Billings and Roberts (2006) explain that the Socratic Seminar is an instructional method that aims to improve understanding of ideas through engaged discussion. Soccio (2015) clarifies that the Socratic Seminar is a dialectical method of inquiry that uses questions to guide a discussion. It is expected that truth comes from learners' discussion (Spencer & Millson-Martula, 2009). Discovering the truth involves a systematic discussion on the nature of verifiable ideas (Spencer & Millson-Martula, 2009). Kessels (2009) adds that it is a collective deliberation of ideas aiming to achieve consensus on the answers to fundamental questions. Attempting to find agreement, instructors can infer that these definitions share two characteristics: first, truth is discovered through engaged and logical discussion; and second, truth comes from within the learner.

Why Use the Socratic Seminar?

Research on Socratic Seminar has shown that it is an effective instructional method both in K-12 and higher education to support academic performance (Griswold et al., 2017; Smith et al., 2009) and meta-cognitive and critical thinking skills (Darginavièienė, 2007; Oyler & Romanelli, 2014). This section examines reasons to use the Socratic Seminar as an instructional method. It first focuses on academic performance. Then, metacognitive and critical thinking skills gained through the Socratic Seminar are discussed.

Because It Improves Academic Performance

The Socratic Seminar can help learners meet K-12 science (Griswold et al., 2017) and English language and arts standards (Schmoker, 2012). Desired learner performance can be seen when the instructor devotes enough time to correctly align Socratic Seminar material (e.g. texts, cases) to standardized tests and national standards (Billings & Roberts, 2006). As an example, Billings and Roberts (2006) found an instructor who linked the standard of writing a "reminiscence about an object, place, or person" (p. 3) with an excerpt from "The Hoard" by J. R. R. Tolkien. The material from "The Hoard" was discussed and modeled to meet the North Standard Course of Study for 10th grade. Regarding science focused courses, analyzing and interpreting data is a crucial part of three core elements of the Next Generation Science Standards (NGSS): crosscutting elements, disciplinary core ideas, and science and engineering practices

(NGSS, 2019). It allows learners to “represent, visualize, analyze, identify patterns, and tabulate data” (Griswold et al. 2017, p. 492). Smith et al. (2013) recommend that instructors start teaching statistical concepts with intuitive notions before moving to definitions and calculations.

In addition, previous research has shown that the Socratic Seminar is a powerful instructional method that can support learners’ conceptual understanding and discourse of data (e.g, Griswold et al., 2017). In a case study, Griswold et al. (2017) found that interpreting graphs, tables, and diagrams using the Socratic Seminar instructional method improves learner outcomes (e.g., discourse of data) and teacher interest towards the instructional method. In their case study, learners examined figures displaying data from the Diabetes Prevention Program that showed diabetes cases under three conditions (placebo, metformin, and lifestyle). Learners’ answered multiple questions ranging from literal (“What do the data show?” p. 494) to interpretative (“What do the data mean?” p. 494) and evaluative (“How might this apply to you?” p. 494). Through group discussions, learners discovered misunderstandings that they had about the data and how to read a figure (Griswold et al., 2017). For example, learners realized that they were not reading the y and x axis correctly and were able to correct the mistake (Griswold et al., 2017). Learner outcomes were measured based on the NGSS and teacher interest in teaching using the Socratic Seminar. Overall, results showed that the role of inquiry in the Socratic Seminar enables learners to learn fundamental concepts intuitively.

Improving academic performance also happens at the college level. Although not strictly Socratic Seminar, previous studies indicate that peer discussion improves understanding of in-class questions for undergraduate learners (Smith et al., 2009). Chowning (2009) argues that “shared inquiry and discussion builds greater learner understanding” (p. 41). In a case study, Smith et al. (2009) found that the percentage of correct answers increased after learners discuss with peers compared to when they did not hold a discussion. They also found that understanding of scientific topics improved even when none of the learners in the discussion groups knew the correct answer (Smith et al. 2009). Instructors can encourage peer discussion and then gradually move to group discussions, aiming to achieve a Socratic Seminar format. Another successful example is Berger and Wild (2017) who found that undergraduates exposed to the Socratic Seminar instructional method improved academic performance as measured by class rank and academic recognitions (e.g., honors degrees). They also found that 94% of learners who engaged in a Socratic Seminar course received honors degrees.

Because It Improves Critical Thinking and Metacognitive Skills

Garrison et al., (2011) define critical thinking as “both a process and an outcome” (p. 8). As an outcome, they explain that learners’ critical thinking is indirectly assessed through individual assignments. As a process, critical thinking is supported through discourse and reflection that demand skills such as creativity and problem solving (Garrison et al., 2011). From a Socratic perspective, critical thinking is defined “as the application and analysis of information requiring clarity, logical consistency, and self-regulation” (Oyler & Romanelli, 2014, p. 1). Thus, critical thinking can be defined as “both a process and an outcome” (Garrison et al., 2011, p. 8). Garrison et al. (2011) explain the process of critical thinking through the practical inquiry model (PIM). The PIM has four phases: triggering-events, exploration, integration, and resolution. Although gradual, these phases are not hierarchical. The process starts by posing triggering events, like questions. Then, learners explore facts and ideas about those questions followed by integration of such through reflection. And, finally, learners resolve questions by testing or defending their solutions.

One can use examples from the literature to understand how critical thinking occurs through the PIM. For instance, Oyler and Romanelli (2014) explain that readily available information (i.e., internet) allows learners to retrieve rote knowledge immediately. One could say that those learners are in the exploration phase of the PIM. Oyler and Romanelli (2014) also argue that fast access to archived information makes critical thinking necessary for learners to avoid empty repetition of facts and be able to connect relevant previous knowledge to new current events (Oyler & Romanelli, 2014). Those learners achieve the integration phase of the PIM in which connections among ideas are made and the real-world. When the Socratic Seminar is used, learners are asked to reason by making inferences, resolve conflicts, solve ill-structured problems, and use evidence to support arguments (Shomoker, 2012). Learners are in the resolution phase of the PIM when they engage in these types of tasks.

Another example of critical thinking is Tempe Preparatory Academy in Arizona which uses Socratic Seminars as model to build their academic programs. At Tempe Prep, learners have daily Socratic Seminars in which they respond to prepared questions about literary and historical masterpieces. On top of that, learners submit monthly essays in which they defend their reasoning about previous topics from the discussed readings (Schmoker, 2012). Learners at Tempe Prep must defend their arguments and interpretations while examining contemporary and historical issues that take them to provide solutions to solve current problems (Veenstra, 2019). In addition, when using the Socratic Seminar individuals learn to regulate their thoughts to find true understanding, which makes this instructional method convenient to nurture metacognition and self-regulation (Darginavièienė, 2007; Oyler & Romanelli, 2014).

In an interventional study, Jensen (2015) examined students' critical thinking skills after implementing the Socratic Seminar three days a week for four weeks. Results showed an increase in critical thinking skills in English Language Learners. Jense (2015) measured critical thinking using the "Holistic Critical Thinking Scoring Rubric" by Facione and Facione (1994) (see the Assessment section below). Similar results have been found with college learners in public relations majors who improved critical thinking and problem-solving strategies in Socratic Seminars in contrast to those who were in a lecture-based course (Parkinson & Ekachai, 2002).

How to Use the Socratic Seminar

The Socratic Seminar first requires learners to read cases, articles, texts, or events in their context or profession (Parkinson & Ekachai, 2002). Second, the instructor, who is familiar with the material, guides learners in a discussion. As a prerequisite to the Seminar, learners must have prepared the predefined material (i.e., assigned text, article, or case). In that way, the Socratic Seminar can meet its purpose of leading learners to discover the underlying principles of a problem and evaluate it (Parkinson & Ekachai, 2002). Consequently, the discussion avoids superficial aspects of a text and immerses learners in deep thinking of complex issues. It is vital that instructors keep the discussion on target and move in the right direction.

Instructors' Role in the Socratic Seminar

Although not explicitly stated in the definitions, a vital element of this instructional method is the instructor. Stoddard and O'Dell (2016) clarify that in the Socratic Seminar, the instructor becomes a guide whose role is not to provide answers to learners, but rather accompany learners in the construction of knowledge. Such knowledge construction happens when teachers ask provoking questions that confront learners' beliefs. Challenging questions intend to make learners reflect and deduce answers through higher-order thinking processes (Stoddard & O'Dell, 2016). Thus, a class becomes a seminar when it takes distance from the traditional idea of the teacher as the provider of all knowledge (e.g., lectures) and learners take agency over their learning (Reich, 2003). Reich (2003) explains that the purpose of the Socratic Seminar explicitly involves not teaching as a sage on the stage, but moving to the guide on the side. A common practice in the Socratic Seminar is to debate ideas and concepts raised by a text, case, or a collaborative discussion (Billings & Roberts, 2006). The purpose of the Socratic Seminar is achieving "a deeper understanding about the ideas and values in a particular text" (Chowing, 2009, p. 38) and nurturing a rigorous intellectual activity in which learners think independently and formulate questions (Acim, 2018) to discover the truth.

The Stages of a Socratic Seminar

Billings and Roberts (2006) from the National Paideia Center describe the teaching cycle of a Socratic Seminar in three stages: planning, practice, and assessment. They explained such phases under the light of the experiences of a teacher who implements the Socratic Seminar during an academic year. The stages' names are similar to any other type of instructional method; it is the role of the instructor that makes a substantial difference in the Socratic Seminar. In this section, readers will find a brief description of each of the stages and recommendations that Billings and Roberts (2006) offer on how to successfully conduct a Socratic Seminar.

Planning

As with any instructional method, planning is the key to success. However, planning for a Socratic Seminar involves two components: 1) instructor preparation (i.e., selecting text/case/event and preparing questions) and 2) learner preparation (pre-seminar individual activities). The instructor preparation component is deliberately based on the curriculum. Therefore, the selection of the instructional material (i.e. the text, case, or event to discuss) goes hand-in-hand with the national standards required for the American K-12 grade level or with expected competencies in the case of higher education. Standard oriented planning guarantees that learners also meet achievement expectations apart from improving critical thinking and metacognitive skills. Furthermore, a good match between standards and instructional materials eases the process of question preparation (see Types of Questions section below).

The learner preparation component aims to nurture skills that are crucial for the development of the Socratic Seminar. Learners need to engage in collaborative and respectful values to participate in fruitful discussions. Pre-seminar activities should foster collaborative values that allow shy learners to speak up and energetic learners to listen actively. There are three ways of fostering learner preparation: 1) establishing clear discussion rules (see Setting Rules and Arranging the Classroom section below), 2) asking learners to set personal goals for the discussion (e.g., minutes of speaking time), and 3) asking for self and peer assessment (see Assessment section below). A good balance between instructor preparation and learner preparation guarantees that both academic goals and socio-emotional goals are met in the Socratic Seminar. Billings and Roberts (2006) explain that the Socratic Seminar can fail if learners are not well prepared, even if instructors invest significant time in the material and question preparation.

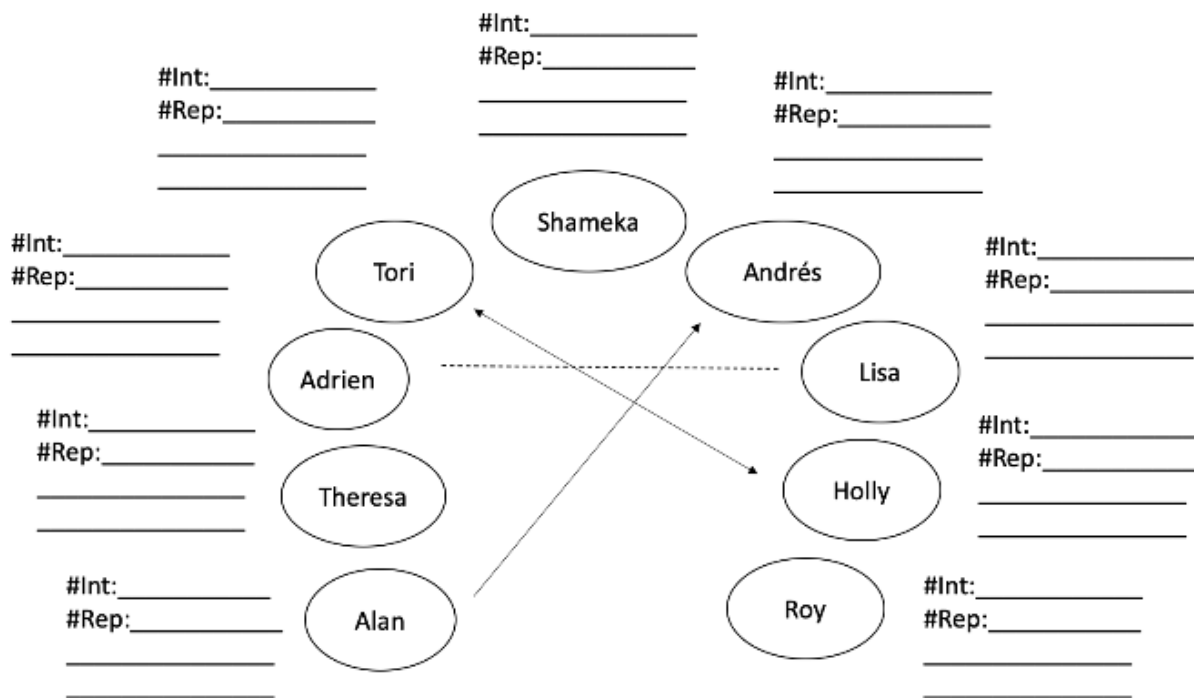
Practice

Instructors must have in mind the intellectual and collaborative purpose of Socratic Seminars. Therefore, questions formulated during the learning experience must be academic-related and intended to promote social interaction. Consequently, purely social questions or questions with only one right answer deviate from the purpose of the Socratic Seminar. In order to achieve fluent discussion, instructors should emphasize that multiple answers exist. In addition, promoting multiple right answers allows learners to confront ideas and debate with their peers in a respectful environment. In that way, learners are encouraged to compare and contrast ideas. Eventually, learners will build upon each other's ideas and synthesize a collective solution to the problems presented.

Guiding a Socratic Seminar requires developed note-taking and active listening skills. Billings and Roberts (2006) recommend that instructors map out their learners in a graphic chart to support the note-taking process (see Figure 1). While learners speak, instructors can quickly locate who the dominant members are, which arguments have been made, and which learner interactions are most predominant. Those notes are necessary to guide conversations based on learners' arguments rather than on instructors' ideas.

Figure 1

Example of Course Drawing to Support Instructors' Note-Taking



Note. #Int.: Number of interventions made. #Rep: number of replies received. One-way arrow: replied to this learner. Two-way arrow: learners exchanged ideas. Dotted line: learners had contrasting opinions.

Assessment

Billings and Roberts (2006) recommend using self and peer assessment after using the Socratic Seminar. Both types of assessments require learners to take ownership of their learning experiences and regulate their behaviors. For instance, Murray, the instructor in which Billings and Robert report, provides her notes to learners when they are doing peer and self-assessment. Moreover, she asks learners to reflect on their personal goals set during the planning phase and ask whether they achieved them or not. Doing so encourages learners to continue defending their positions, much like during the Socratic Seminar itself. Using learners' personal goals, instructors' map of interactions, and learners' annotations allows participants of the Socratic Seminar to make data-driven assessments of their performance. Assessment does not only happen among learners; instructors are highly encouraged to use their notes to continue improving the Seminar facilitation and the overall learning experience. Instructors can support their assessment using Facione and Facione (1994) Holistic Critical Thinking Scoring Rubrics. Instructors can assign learners points from one to four depending on their demonstration of critical thinking traits. A description of the highest score is "Thoughtfully analyzes and evaluates major alternative points of view." Descriptors of low critical thinking are "Offers biased interpretations" and "Does not justify results or procedures, nor explain reasons."

Practical Considerations

Types of Questions

Questions are the building blocks of the Socratic Seminar and instructors use them to build a strong, solid environment to engage learners in constructive discussions. Questioning also involves purposefully selecting questions that encourage learner-to-learner interaction instead of only instructor-to-learner interaction. In Table 1, instructors will find a set of questions to use when guiding a Socratic Seminar and the intended purposes of each question. Before using the questions presented here, it is critical that instructors assess a learner's existing knowledge to select questions that challenge learners without frustrating them (Stoddard & O'Dell, 2016). Stoddard and O'Dell (2016) group Socratic Questions in three clusters: questions to clarify concepts, questions to probe evidence, and questions to explore

implications or consequences. Table 1 is a compendium of questions posed by different researchers' rationale (Griswold et al. 2017; Saran & Neisser, 2004; Stoddard & O'Dell, 2016) and aligned with Krathwohl's revised version of Bloom's Taxonomy (Stoddard & O'Dell, 2016). Instructors can use this table to match questioning to national and state standards.

Table 1

Types of Questions for Socratic Seminars

Krathwohl's revised Bloom's taxonomy (2002)	Saran & Neisser (2004) – General Socratic Seminar Questions	Stoddard & O'Dell (2016) – Questions focused on medical settings useful for case studies.	Griswold et al. (2017) – Questions focused on database Seminars.
Remember	Asking for Clarification	Questions to Clarify Concepts	Literal Questions
Recognizing, recalling	What do you mean when you say___? Can you elaborate___? Can you explain further___?	What does this mean? What is the origin of this?	What does the data/chart/table/graph show? How are the x- and y-axis labeled? Why are they labeled that way? Does the title of the data/chart/table/graph clearly depict it?
Understand	Probing Assumptions	Questions to Clarify Concepts	Interpretative Questions
Interpreting, explaining, comparing, summarizing	What are you assuming when you say___? Are your arguments based on the assumption that ___?	How does this relate to what we have been discussing/learning? What do you already know about this topic/issue?	What does the data mean?
Apply	- N/A -	Questions to Probe for Evidence/Rationale	- N/A -
Executing, implementing		Can you give me an example of what you said___? How did you learn/practice that?	
Analyze	Probing Evidence	Questions to Probe for Evidence/Rationale	Interpretative Questions
Differentiating, organizing	How does your argument apply in the case of ___? In what evidence do you base your argument ___? What is an example of ___? Viewpoints & Perspectives Why are you taking this viewpoint instead of the other? How would people	How does X affect Y? Then what would happen if....? Why is that issue happening? How do you know this is the issue?	Can this data be used to support a specific claim?

Krathwohl's revised Bloom's taxonomy (2002)	Saran & Neisser (2004) – General Socratic Seminar Questions	Stoddard & O'Dell (2016) – Questions focused on medical settings useful for case studies.	Griswold et al. (2017) – Questions focused on database Seminars.
	from other backgrounds react to___?		
Evaluate	Implications & Consequences	Questions to Explore Implications/Consequences	Interpretative Questions
Critiquing	What are the implications of your idea/argument/position ___? What effect would that idea/position have on ___ situation?	Why is that important? What are the implications of X decision?	Does the data have consequences? What are the social/economical/cultural consequences of this data? Evaluative Questions (Meta-cognitive) How does data apply to you? What experience do you have with this?
	Questions about the question (Meta-questions) Why is this question important? How do you think we can answer this question?		
Create	- N/A -	Questions to Explore Implications/Consequences	- N/A -
Generating, producing		Based on the history and physical condition of the patient, can you give a diagnostic? What can we do now to treat her?	

Note. - N/A - : Authors did not provide questions for that level in the taxonomy.

Setting Rules and Arranging the Classroom

A Socratic Seminar needs a set of rules for participants to take the most out of it. For instance, learners need to time their interventions (Griswold et al., 2017). In that way, Seminar time is more evenly distributed, and participants have more chances to intervene in the discussion. Also, learners should have prepared materials (e.g., text, cases) beforehand and be prepared to listen to others' arguments. Learners could be encouraged to refer by name to others while discussing and to avoid raising hands to promote the natural flow of the discussion. Finally, instructors are encouraged to plan in advance the classroom arrangement. Griswold et al. (2016) suggest using a horseshoe or circle in which learners can see each other. However, they understand that roundtables are not always possible and offer an alternative for large classes: the fishbowl arrangement. Fishbowl means that there are two concentric circles facing inwards. The circle in the center contributes to the discussion while the outer circle listens and waits for their turn to contribute. Members of the outer circle can do peer evaluation using predefined rubrics (Billings & Terry, 2006).

Other Considerations

The Socratic Seminar does not mean pinging (Oyler & Romanelli, 2014), also referred to as toxic quizzing (Purdy, 2018). Pinging is a popular instructional method in the field of medicine "where persons in power ask questions to their junior

colleagues” (War et al., 2005, p. 185). For the sake of clarity, the term toxic quizzing will be used. Both the Socratic Seminar and toxic quizzing require instructors to question learners’ ideas (Stoddard & O’Dell, 2016). However, toxic quizzing intends to provoke admiration towards instructors and portray them as superior to their learners. In comparison, instructors apply the Socratic Seminar when asking questions to ascertain learners’ previous knowledge (Tofade et al., 2013) and synthesize new information (Stoddard & O’Dell, 2016). Questioning becomes toxic quizzing when instructors’ intentions do not pursue curiosity, but intend to belittle learners (Stoddard and O’Dell, 2016). Therefore, the instructor’s role is vital as they establish a safe space for sharing ideas and encouraging intellectual autonomy.

Although the Socratic Seminar highly encourages independent thinking, unguided instruction could be adverse to learners’ performance (Kirschner et al., 2010). For the novice and intermediate learners, Kirschner et al. (2010) found that instruction with minimal guidance framed under the constructivist approach (like the Socratic Seminar) was not superior to direct instructional guidance. For more advanced learners, minimal guidance was equally effective as direct guidance (Kirschner et al., 2010). Although scientific thinking can occur without guidance, Kirschner et al. (2010) argue that teaching scientific thinking does not have to be the same as the epistemology of science. Furthermore, they say that it is “a mistake to assume that instruction should exclusively focus on application” (p. 84). In the case of the Socratic Seminar, the instruction is the application of scientific thinking itself. Hattie and Donoghue (2016) explain that the low efficiency related to problem-based or inquiry-based methods is due to using them on learners who have not acquired sufficient prior knowledge yet. Practitioners are recommended to assume that higher-level thinking skills require enough prior knowledge when using minimal guidance in instruction (Hattie & Donoghue, 2016). Thus, this chapter strongly encourages practitioners to know their learners before embarking on any instructional methods and to think of pre-planning as the most relevant part of the Socratic Seminar—more relevant than the discussion itself.

Figure 2

Infographic on the Socratic Seminar

THE SOCRATIC SEMINAR

The Socratic Seminar is an instructional method that aims to improve understanding of ideas in a text through engaged discussion (Billings & Roberts, 2006).

1 Truth comes from within the individual

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Visual Aesthetics

The Art of Learning

Dennis West, Bohdana Allman, Enoch Hunsaker, & Royce Kimmons

Instructional design lies at the crossroads of both the educational tradition (instructional) and the artistic tradition (design). Design is, of course, a complicated term due to its operationalized usage in the fields of art and engineering (e.g., graphic design, industrial design, architecture), as well as its universal meanings (Design, 2012). In artistic contexts, design connotes aesthetics as evaluative criteria while in scientific contexts it connotes functionality as evaluative criteria. Instructional design is a bit of both—art and science. An effective learning experience often includes the meeting of instructional objectives, which is part of the science of learning, but also the proverbial “lighting of a fire,” or the art of learning. This is the primary value of aesthetics in instructional design: “the bridge between [an instructional] product and the user’s emotion and feeling” (David & Glore, 2010, para. 6).

The word aesthetics originates from Ancient Greek words meaning “sensitive,” “perceptive,” and “to feel” (Aesthetic, 2011). The aesthetic and related ideas have a rich presence in philosophy dating at least as far back as Plato (Pappas, 2016), and more recent thinkers (Dewey, 1934/2005; Robinson, 2010) have applied the ideals of the aesthetic to the domain of learning. An aesthetic experience is one that is “heightened and intensified” (Dewey, 1934/2005, p. 306; Parrish, 2009) and “when [the] senses are operating at their peak” (Robinson, 2010, 5:55), as in when a user is in a state of flow (Csikszentmihalyi & Robinson, 1990). Some argue that this type of intensified, enlivening experience needs to play an increasingly crucial role in modern education. As Robinson (2010) puts it, “We shouldn’t be putting [students] to sleep [i.e., anaesthetizing them]; we should be waking them up to what they have inside of themselves” (5:55). While the aesthetics of a learning experience encompass a variety of factors, this paper will focus primarily on the visual aesthetics (or visual design), which includes graphics, images, and a variety of other visual elements in instructional objects (e.g., textbooks, e-learning modules, etc.) that are created by instructional designers.

Within the field of instructional design, we have sometimes observed a hesitation to dwell on visual aesthetics (Parrish, 2009). This hesitation may stem from concern that artistically-approached designs will lack the ability to be replicated (Merrill & Wilson, 2006) or that the artistic elements will serve merely as window dressing—or worse, distraction—that provides no educational benefit to the learner. Additionally, many instructional designers lack training in visual literacy (Clark & Lyons, 2010; Malamed, 2015). Research and practice increasingly recognize that visual design does impact many aspects of the learning experience. It “affects the quality of learning, the value of the communication, and the motivation of the audience members. It leverages the brain’s innate capabilities, improves engagement, and satisfies the audience’s aesthetic sensibilities” (Malamed, 2015, p. 4).

In the age of highly visual multimedia, “we need guidance on the best use of visuals for learning” (Clark & Lyons, 2010, p. i). This paper aims both to raise awareness of the importance of visual aesthetics in instructional design and to provide some initial guidance for instructional designers in the process of creating and/or evaluating the visual aesthetics of what they produce.

How Visual Aesthetics Impact Learning

We as humans are deeply attuned to aesthetics. Our immediate perception of an object—in our case, a learning design—affects us on a visceral level, instantly making the object attractive or repellant to us (Norman, 2004). This emotional judgment, which occurs much faster than deliberate cognition, frames subsequent thoughts and has a strong impact on our future thinking and actions (Malamed, 2015; Norman, 2004). Ultimately, visual design influences and connects both emotional and cognitive aspects of the learning experience. Quality visual design piques interest, calls attention, and increases engagement and motivation while simultaneously improving communication, supporting cognitive processing of complex ideas, aiding retention, and fostering creativity. The following sections will discuss each of these ideas in more detail.

The Impact of Visual Aesthetics on Affective Aspects of Learning

Research suggests that the visual aesthetics of an object significantly impact a person's emotional response, both initially and over time. Taking into account a learner's emotional state is becoming an increasingly important aspect of instructional design. Gagne posited that gaining the attention of the learner is the first event of instruction (Kruse, n.d.); and attention and interest, which are interconnected and mutually dependent, are among the first emotional responses influenced by visual design. As learners pay attention to instruction, their interest often develops or changes over time; and that interest, in turn, affects their attention. The level of attention and interest further influences the learner's engagement and motivation to learn and achieve long-term progress in their educational goals (Järvelä & Renninger, 2014). Thus, appealing visual design ultimately affects users' motivation to engage and persist in the learning process (David & Glore, 2010). Each of these emotional states—interest, attention, engagement, and motivation will be discussed in the following section.

Interest. Attention, the mental focus demonstrated by the learner, is directly influenced by both the learner's individual interests and the interestingness of the learning material (Park & Lim, 2007). Learners' individual interests are specific to each individual, and since they are relatively stable, it is often quite challenging to design instructional material or a learning environment that would attend to all learners' diverse interests. On the other hand, situational interest is generated as an outcome of interestingness, or overall appeal. It is an emotional state triggered by specific features, including the visual design of a product or task within a learning environment, and this situational interest directly affects learners' attention (Park & Lim, 2007). This triggered situational interest has great value as it may develop into a maintained situational interest and possibly into an emerging or developed individual interest. The level of interest affects motivation and engagement of the individual learner and leads to curiosity, self-regulated learning, and deeper processing of information (Järvelä & Renninger, 2014).

Attention. Graphics hold attention longer than text, and graphical information is extracted with greater ease than textual information (Malamed, 2015). Aesthetically appealing visual design can capture, hold, and focus the learner's attention and their interest in the content (Haag & Snetsinger, 1993). When learners encounter an instructional product, the visual aesthetics of that product immediately issue an "intuitive invitation" (Haag & Snetsinger, 1993, p. 95)—either positive or negative—into the environment created by that product. This intuitive invitation exists because of the aesthetic impact on both the learner's interest and the learner's immediate judgment about the credibility of the product's content and the usability of its interface (David & Glore, 2010). These immediate judgments and their lasting effects can impact learners' attention, interest, motivation, engagement with the material, and performance on learning assessments (Haag & Snetsinger, 1993). Regardless of the medium, images of people and faces, bright colors, striking shapes, and motion draw learners' visual attention better than text without images (Malamed, 2015), and visuals should serve representational or explanatory functions in instructional materials to increase interest and attention and to intentionally promote learning (Clark & Lyons, 2011).

Engagement and motivation. Malamed (2015) explained that positive emotions experienced through visually pleasing instructional design or its elements can foster intrinsic motivation, which refers to the desire to learn without an external reward. Park and Lim (2007) found that both cognitive interest illustrations (i.e., graphics that promoted structural understanding of an explanation) and emotional interest illustrations (i.e., graphics that were interesting but

irrelevant to the text structure) had a positive impact on promoting learners' motivation toward the instructional material, especially in terms of relevance. Well-designed graphic elements can affect users' motivation to "engage and persist" in the learning experience (David & Glore, 2010). Additionally, aesthetically pleasing objects, including instructional materials, are perceived as more user-friendly than are displeasing objects, and this perception, in turn, affects learner's engagement and motivation (Malamed, 2015).

Emotions influence human attention, motivation, engagement, and ultimately the outcome of the learning experience (Pekrun, 2006). Thus, taking into consideration a learner's emotional state is essential in the process of instructional design. A positive user experience creates a positive emotional state that influences the entire learning process and persists even after the learning event is completed. Activating positive emotions through an intentionally aesthetically-pleasing design contributes to a positive learning experience by influencing attitudes and motivation, increasing students' interest, and strengthening their attention and level of engagement with materials (Malamed, 2015).

The Impact of Visual Aesthetics on Cognitive Aspects of Learning

In addition to the extensive impact on emotion, visual aesthetics exert a strong influence on cognitive aspects of learning as well (Um, Plass, Hayward, & Homer, 2012). Visual elements do more than make an object look nice; they are an integral component of its ability to communicate the message (i.e., instructional content) to the user (i.e., learner). Simple, relevant, and effective visual design reduces extraneous cognitive processing and provides an additional mental channel for the most important information (i.e., the content) to be processed and retained.

Improving communication. Visuals aid in communication of information in several ways. Visuals facilitate semiotic communication, which is conveying information through symbols, signs, and elements. Visual communication occurs on a much deeper level than common language, cultivates interest, impacts emotions, and brings cultural concepts to mind (Amare & Manning, 2012). Visuals also emphasize details, demonstrate relationships, and improve understanding. Graphics, such as simple icons, elaborate illustration, and complex data visualization, support and facilitate thinking, problem solving, and learning by providing rich and textured language for expressing ideas. (Malamed, 2015). Diagrams or charts quickly communicate relationships, which may be more difficult to convey through text alone. Visuals in general "help learners understand complex text or narration because they convey information about spatial structure," which provides additional meaning (Malamed, 2015, p. 6). This structural organization of an image provides a certain level of scaffolding, which aids in construction of new mental models and facilitates processing and comprehension of the text (Eitel, Scheiter, Schuler, Nystrom, & Holmqvist, 2013).

Supporting cognitive processing. Visual perception is faster than thinking. Our brains devote more resources to processing visual information in comparison to auditory or other senses. If a graphic is clear and easy to understand, visual information can be decoded and processed rapidly (Malamed, 2015). Additionally, the brain processes verbal and visual information differently. When both of these channels—verbal and visual—are activated in a common task, giving the mind "two opportunities to build meaning," instructional products are most effective (Clark & Mayer, 2012, p. 314). For instance, Levie and Lentz (1982) reported in their synthesis of 46 studies that students who read illustrated text learned approximately one-third more about the specific points that were illustrated than students reading text alone.

Not all images are equally effective in supporting learning and creating a deeper understanding, however. The implementation of graphics ranges from simple diagrams that support textual content to rich visual illustrations that may increase motivation but may fail to promote learner comprehension. Clark and Mayer (2012) noted that images are usually most effective when they either eliminate extraneous elements or highlight the most relevant ones, but there is no simple formula that can be used to design or select visuals that improve learning and performance in all situations. Clark and Lyons (2010) further suggest that the learning value of a visual depends on three factors: (1) features of the visual itself, (2) the goal of instruction, and (3) the learners' differences, which go beyond the visual elements discussed in this paper. They introduce a comprehensive framework where features of graphics include the surface features (salient characteristics of the piece), communication function (decorative, representational, interpretive, etc.), and psychological function (support attention, minimize cognitive load, build mental models, etc.). The goal of instruction factor refers to the idea that different types of visuals are needed to effectively support learning of different content

type (facts, concepts, processes, procedures, and principles). The learners' differences factor suggests that it is learners' prior knowledge of content, rather than their learning style, that most affect the value of graphics. For example, novice learners benefit much more from added graphics than do more knowledgeable learners because they have already formed internal visual imagery related to the content (Clark & Mayer, 2012). Clark and Lyons (2010) explain that it is important for instructional designers to understand these guidelines as the effective use of visuals varies depending on the unique mix of learners, specific learning goals, and content to be learned.

Retention of information and memory. Effective visual design supports not only initial cognition but also retention of the material. Images capture and hold attention longer than text, and concrete things are typically remembered better than abstractions (Malamed, 2015). Retention is best aided when the information has a "high correspondence to the verbal message" (Levie & Lentz, 1982), increasing the likelihood that visual information will be stored directly in the long-term memory of the learner (Haag & Snetsinger, 1993). For this reason, an effective use of visuals aids retention while an ineffective use of visuals can actually distract the learner from the intended learning outcomes (Clark & Mayer, 2012; Haag & Snetsinger, 1993). Additionally, some types of graphics, such as graphs, diagrams, and infographics, facilitate the process of making inferences and serve as an external memory aid through an intentional and meaningful organization of information (Malamed, 2015).

The Impact of Visual Aesthetics on Creativity

Visual aesthetics have a somewhat indirect, yet profound impact on creativity through stimulating positively valenced emotions, or positive affective response (Isen, 2002). In a way, creative thinking is the nexus where affective and cognitive aspects of learning meet to produce something truly wonderful: the ability to use both understanding and feeling to solve existing problems and expound, extend, question, and in turn create something unique and new. As mentioned earlier, emotions regulate how we solve problems and perform tasks. Negative emotions, such as anxiety, fear, and even anticipation, focus the mind and narrow concentration, leaving people less susceptible to interruption or distraction (Norman, 2002). Having the proper amount of negative emotions (e.g., facilitating anxiety) may help a learner focus and do their best; but when the negative affect is too strong, as in a case of debilitating anxiety, performance is inhibited (Isen & Reeve, 2005; Moyer, 2008). Positive emotions, such as enjoyment, interest, and inspiration, broaden the thought processes and enhance creative thinking. This state of mind is conducive to learning, problem solving, and innovation because positive emotions enable more flexible and adaptive thinking, which aids in accomplishing difficult tasks (Isen & Reeve, 2005; Norman, 2002). In fact, many studies indicate that "positive affect promotes flexible, adaptive thinking that is creative and at the same time effortful, effective, thorough, and responsive to the details of the problem and the context" (Isen, 2002, p. 57). Pekrun et al. (2006) also proposed that the pleasure students feel when learning, which may be in part induced by an enjoyable aesthetic encounter, correlates positively with their experience of flow, or a complete immersion into an activity. As suggested by Csikszentmihalyi, this state of flow brings about creative thinking and innovation (1996).

In sum, visual aspects impact emotion, cognition, and creativity. These influences are circular and recursive. Emotions impact cognition and cognition impacts emotion; both influence creativity, and creativity, in turn, fosters deeper thinking and increased positive affect. Visual design is admittedly only a part of this process, but research suggests that its impact on learning is indeed significant.

Improving Instructional Design through Visual Aesthetics

While an instructional designer needs to attend to all aspects of the design, Gibbons (2014) reminded us that "everything depends on what the designer chooses to see as being important" (p. xx). The implication is that a designer may be inclined to focus or specialize on particular elements of the design, such as the content, the media, or the strategy. Often, however, the instructional designer does not have the luxury of outsourcing the visual-aesthetic aspects of the design. This can be problematic if the designer feels "that visual literacy belongs to the domain of a talented few" (Clark & Lyons, 2010, p. xiii) and does not feel qualified. For this reason, we are providing this section as a brief guide to

instructional designers to aid in their efforts to create and evaluate the aesthetic quality of visual elements in their designs.

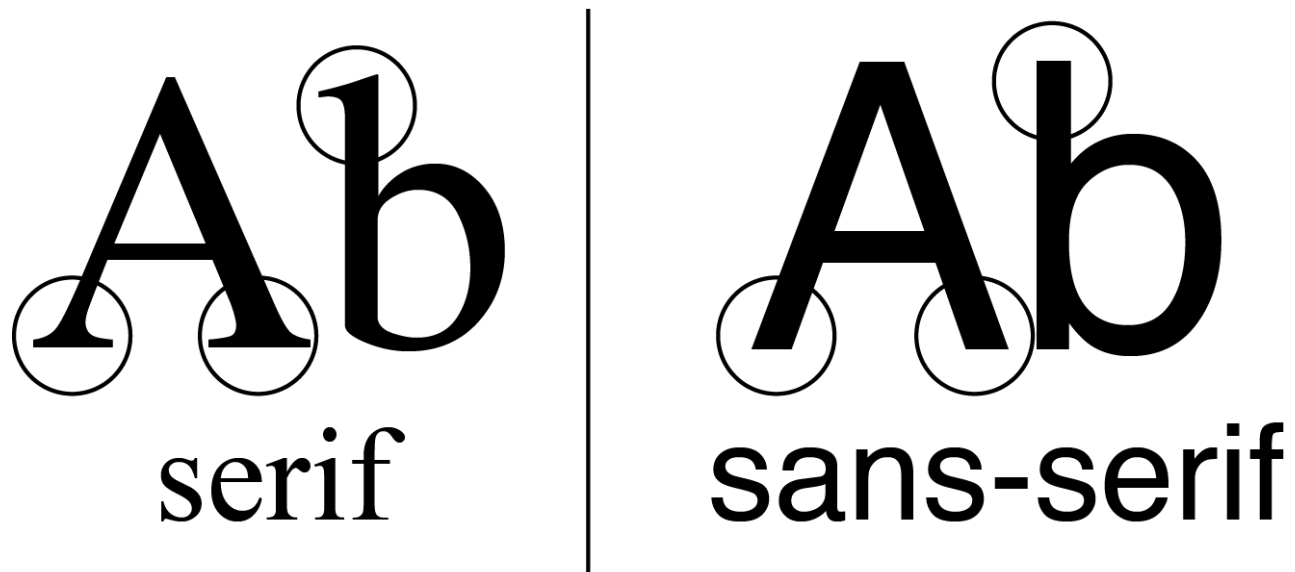
In instructional design, visual aesthetics refers to “the integration of individual visual elements that combine” to “promote communication between the student and the program in order to cultivate learning” (Haag & Snetsigner, 1993, pp. 92-94). There are six foundational elements of graphic design that every instructional designer can use to guide the visual design of their object: (1) fonts, (2) colors, (3) organization, (4) iconography and semiotics, (5) theme, and (6) appeal. These elements do not represent a comprehensive list but are intended as a starting point for further investigation in evaluating and improving the visual aesthetics of instructional designs.

Fonts

The font, or typeface, chosen for the text deserves careful consideration since it can affect readability (Poole, 2012; Malamed, 2015) and impact emotions (Koch, 2012). Fonts can also contribute to or reduce visual clutter by controlling how many typefaces and styles of fonts are used in a single design. Typically, two complementing typefaces are a good standard to work from—a headline font that may be more decorative and a text font that is more readable (Kliever, n.d.). When choosing fonts, the most basic feature to consider is whether the font is serif or sans-serif (see Figure 1). Which type of font is more readable depends on the type size, quantity of text, and the audience. Young readers may find the letterforms in sans-serif fonts to be more identifiable, and sans-serif fonts can be more legible at small sizes. Serif fonts have a more classic and familiar feel and may be more comfortable to read when used for long text entries (Poole, 2012).

Figure 1

A serif is the bracket terminating a stroke of a character in a serif font as circled. A sans-serif font is without that feature.



- Left-justify text, make it large enough to read, keep size and style uniform; centered text is rarely appropriate outside of headings
- Select a theme-appropriate font (comic sans for learning about medical treatments is probably a bad idea)
- The more prevalent a font is in your materials, the less-complex it should be; a swirly font might be used for a logo, and a somewhat wavy font might be used for headings, but a simple font should be used for the main content; just because a font exists does not mean it should be used
- Use variation sparingly (e.g., bold, italics), and only when it adds to the meaning of the content; your purpose for variation should be clear (e.g., a callout box for a key concept); 90-9-1 rule? 90% of your text should be simple, 9% can be somewhat fancy, and 1% can be extra fancy
- Never use different fonts for the same type of content; two fonts is okay if one is used for headings and the other for body text; three or more fonts is almost never advisable

Colors

The message and emotion can be influenced by the choice of color (Malamed, 2015). As well as impacting emotion, colors also have cultural significance of which designers should be cognizant when creating designs with an international audience (Madden, Hewett, & Roth, 2000). A defined color palette can enhance the visual language as well. For usability purposes, a color can become associated with a certain task or type of content which will aid the learner in navigating as well as in interpreting the meaning of figures and drawings. Furthermore, research shows that the use of certain colors and applying emotional design principles to learning materials can induce and maintain positive emotions while viewing instructional materials, which in turn facilitates learning (Um, Plass, Hayward, & Homer, 2012).

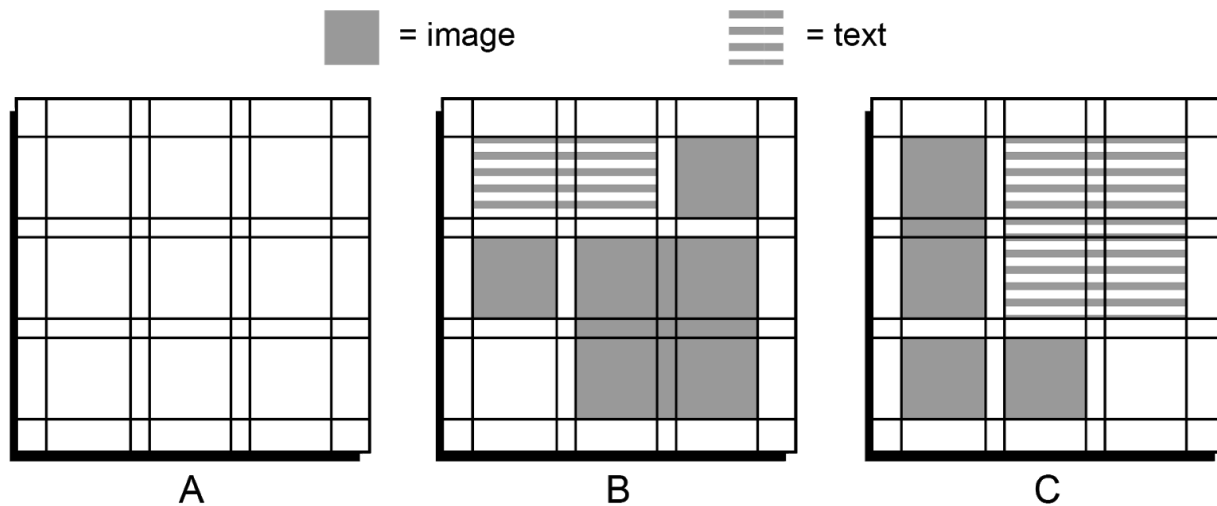
- Select a color scheme, monochromatic, etc.; you should generally pick one color as your primary color, coupled with a white, cream, or light gray for backgrounds, and then only use one to three additional colors as accents
- Choose a palette, use existing tools like <http://color.adobe.com> to find community-generated palletes or to generate a palette directly from a pleasing or related image
- If gradients in material elements are to be used, they should be subtle, avoiding stark shifts
- High-contrast colors are helpful for drawing attention, improving accessibility, and reducing color

Organization

Every element on a screen or page in an instructional object requires the attention of the learner in order to process. Any unimportant or distracting elements must be diminished or removed so that distraction or confusion may be eliminated. Consistent placement of related elements from page-to-page aid in orienting the learner on where to find content (Müller-Brockman, 1996). A typical method of accomplishing this in graphic design is to develop a grid system, as shown in Figure 2, that will be followed throughout the publication. The established grid will standardize the placement of text and images into patterns that will become predictable to the learner and will reduce the cognitive load required to orient themselves each time a new page is encountered, thus greatly improving usability. In addition to a predictable layout, any embellishment on a shape or graphic element, such as an outline or drop shadow potentially adds to the visual clutter of the page. If such elements aren't justified by the needs of the visual presentation it is important to recognize that they may distract from the message.

Figure 2

A grid system defines the alignment of margins and columns, and it standardizes placements of text blocks and images in a layout. Page A represents a blank page with grid guides that will be invisible in the end product. Pages B and C show two layouts using the same grid system that establishes a pattern for predictable placement of text and images while providing the designer flexibility in their arrangement.



These organizational aspects of aesthetics reduce the negative emotions a learner may feel when they are presented with materials that are difficult to visually navigate in order to find needed information (Clark & Lyons, 2010; Malamed, 2015). In order for cognition to be focused on the content and metacognitive processes required for assimilation, visual design should focus on minimizing the cognitive load required to navigate and interact with the medium (Kirsh, 2005). Thus, “usability, simplicity, and clarity” (Kirsh, 2005, p. 148) emerge as guiding principles of effective visual design.

- Use a grid
- Organize your content according to your culture’s reading direction (left-to-right, top-to-bottom)
- Use borders, lines, and horizontal rules carefully and only to intentionally disrupt your viewer’s flow
- Avoid mixing 2d and 3d elements, and recognize that layered or stacked content conveys a sense of importance (we focus on what is on “top”); shadows convey a sense of depth that can be helpful or confusing

Icons

When using icons and symbols, it is important to make sure that they are easily understood. If the audience isn’t well versed in the visual language, there must be a legend provided to orient the learners. Visual design concerns the semiotic communication that occurs with symbols, signs, and elements. It cultivates interest, impacts emotions and brings cultural concepts to mind. When choosing graphics to embellish or enhance an instructional design, a knowledge of the audience and cultural implications of certain graphics or symbols is important. Unintended messages might be conveyed which could distract from the purpose of the design (Amare & Manning, 2012).

- Use them to draw attention to commonly used or important elements; supplement with brief text descriptors (preferably action words) when they are used as buttons
- Make icons minimalist and intuitive (Fig. for minimalist vs. non-minimalist icon); as a rule, the larger the icon the more detail you can include (compare Mac OS X icons to Google Docs interface icons)
- Make icons universal in your product (don’t use multiple “user” icons), monochromatic, and scalable with transparent backgrounds (to allow for reuse and application in various settings) (.svg, .ai for scalability; .png for transparency)

Theme

A theme coordinates organization and all graphical elements into a unified whole. It influences a selection of fonts, colors, and images used in the overall design (Malamed, 2015). A well-elected theme can cement the message of an instructional object. The theme can transport the learner into the world of the subject matter. For example, cursive headline fonts, earth tones, and parchment paper patterns would be appropriate for a course teaching the plays of Shakespeare, whereas sans-serif fonts, saturated primary colors, and images of planets may be appropriate for

teaching about space exploration. A theme may add intuitive reinforcements to the message of the learning object and adds to the overall aesthetic experience of the design (Malamed, 2015).

- Know your audience (the A in ADDIE)
- Connect your colors, layout/organization, fonts, etc. to tell a common story (e.g., Comic Sans should not be used for a technical subject)

Appeal

Ultimately, one of the most useful questions instructional designers can ask of their work is if it is appealing to them or not. An individual who is not trained as a graphic artist might discount their ability to judge the aesthetic quality of their work, but they still have the ability to decide the assortment of clothes they wear from day to day. In reality, many creative individuals simply strive to make things that they personally like. In the process of doing so, they serendipitously generate materials that appeal to others' sensibilities as well.

- Aesthetic responses are intuitive, aesthetic design is not
- Take a break, similar to olfactory overload, and come back later
- Put your design in front of people, watch how they use it, and listen carefully to their initial reactions (if you have to argue for the merits of the design to them or explain how they should use it or feel while they are using it, then it is a bad design)
- Attention should be drawn to your theme, not the design itself; elements that are distracting or self-focused should be avoided

Conclusion

Considering the ultimate aim of any instructional object to be the optimum learning for the student, the aesthetic appeal of that object must be purposefully considered by the instructional designer. Otherwise, their inattention to the visual aspects of their work may result in a product that distracts the student from the message being communicated and fail to motivate them to further learn. Visual aesthetics may present a beneficial service to the learner if they are tailored to provide a positive emotional experience. This positive emotional experience will then aid in increasing interest, motivation, cognition, and creativity. Although many instructional designers may not view themselves as graphic artists, attention to common details such as fonts, colors, icons, theme, and appeal will go far in providing an aesthetically appealing learning experience. This article was intended to raise awareness of the importance of visual aesthetics in instructional design, to pique interest in the topic, and give initial guidance. The authors encourage instructional designers to seek and develop their skills of the best use of visuals for learning. We strongly recommend great resources, such as Design Aesthetics for the Web on Lynda.com, Graphics for Learning by Ruth Clark and Chopeta Lyons (2010), and Visual Design Solutions by Connie Malamed (2015).

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List of Authors



Bohdana Allman

Bohdana Allman is an educator, researcher, and learning experience designer. Her work focuses on designing and implementing online collaborative teacher professional development grounded in sociocultu...



Matthew Armstrong

Brigham Young University



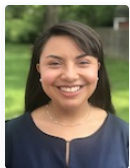
Arpit Bawa

Purdue University



Bekki Brau

Brigham Young University



Daniela Castellanos-Reyes

Purdue University

Daniela (Ela) Castellanos-Reyes is pursuing a Ph.D. in Learning Design and Technology at Purdue University. Her research interests are the community of inquiry framework, quantitative research methods...



David Daniel

Brigham Young University



Cade Dopp

Brigham Young University



Alyssa Erickson

Brigham Young University



Justin R. Evans

Brigham Young University



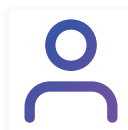
Holly Fiock

Purdue University



Nathan Fox

Brigham Young University



Susanna Fullmer

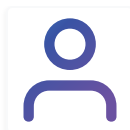
Brigham Young University



Enoch Hunsaker

Brigham Young University

Enoch Hunsaker is an Instructional Designer at Brigham Young University Online. He graduated with a Master's degree in Instructional Psychology and Technology from the same university in 2018. He has...



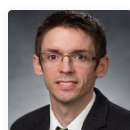
Matt Karlsven

Brigham Young University



Bill Kemsley

Brigham Young University



Royce Kimmons

Brigham Young University

Royce Kimmons is an Associate Professor of Instructional Psychology and Technology at Brigham Young University where he seeks to end the effects of socioeconomic divides on educational opportunities t...



Jeanine Lundell

Brigham Young University



Esther Michela

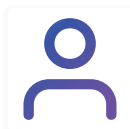
University of Tennessee

Currently a PhD student at the University of Tennessee Knoxville, Esther is exploring issues of accessibility, empathy, Universal Design for Learning, and student interaction in the context of instruc...



Spencer B. Perry

Brigham Young University



Phillip Isaac Pfleger

Brigham Young University



Elizabeth Robinson

Brigham Young University



Micah Swartz

Texas State University

Micah Swartz is a Mathematics Education Ph.D. student at Texas State University and is a 2022 recipient of the National Science Foundation Graduate Research Fellowship. Currently, he is collecting dat...



Jesse Welsh

Brigham Young University



Dennis West

Brigham Young University



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