The Students' Guide to LEARNING DESIGN & RESEARCH

Royce Kimmons, PhD

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Royce Kimmons

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About this Book

This book is a continually-evolving class project for my 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.

Additionally, instructors are welcome to encourage students to submit class papers as chapters to this work.

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Learning Theories

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.

Oneexperiment 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 shap 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

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

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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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 though 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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Methods

Case Studies

Alyssa Erickson

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

Isaac Pfleger

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

1959	1960	Difference
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).

H0: The average of 1959 = the average of 1960. (i.e the difference = 0)

Ha: The average of 1959 ≠ the average of 1960. (i.e the difference ≠ 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.

Fig. 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):

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

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 instruction 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 and 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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Design and Development

Copyright

Elizabeth Robinson

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

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 end result as one single object (like how I saw my car), but there are a number of 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

Responding to those choices, the representation layer entails what is actually 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 the 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 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 in 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, it is likely that designers at Lynda are 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 own 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 technology 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 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 hinderance for 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 a number of 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, & 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, a 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 anthe 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). [http://edtechbooks.org/-ZB]

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, p. ?). 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, p. ?). 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, p. ?). 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, p. ?). 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, p. ?). 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, p. ?). 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, p. ?). 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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Project-Based Learning

Spencer B. Perry

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.

Keywords

inquiry, authentic learning, project based learning, PBL

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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.

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.

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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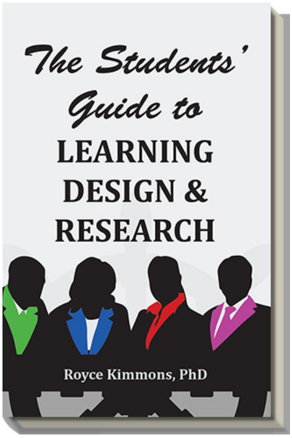

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