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BOOK REVIEW

Metaphors for Learning: a Guide for Teachers

Kevin J. Pugh. (2017) Computers, Cockroaches, and Ecosystems: Understanding Learning through Metaphor. Information Age Publishing, Inc. Charlotte, NC. ISBN: 978-1-68123-776-3, 172 pages, price: $45.99 (paperback)

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1 Introduction

People such as Richard Feynman are insatiably curious; they have an innate desire to discover new knowledge. But learning is more than pure brilliance. It is important for everyone and, as teachers, we need to understand how to maximize the learning potential of our students. The study of human cognition is a rich field that has produced many fruitful theories of learning. As an educator (new or experienced), it can be difficult to keep track of the many theories that have been developed over the years. *Computers, Cockroaches, and Ecosystems* is an easily accessible traveler's guide to four major learning theories: behaviorism, cognitivism, constructivism, and socioculturalism. Pugh states that his goal is to "popularize the core principles of learning valued by learning experts" (p. 3). He does this by introducing a different theory of learning in each chapter and situating each theory in a modern educational context in order to show how each one of them impacts teaching and learning in the classroom. The author further employs the compelling strategy of explaining each learning theory through metaphor.

Metaphor theory provides a method for dissecting how people understand complex, abstract concepts. As pioneers in the field of metaphor theory, George Lakoff and Mark Johnson explain: "Metaphor is pervasive in everyday life, not just in language but in thought and action. Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature" (*Metaphors We Live By*, 1980, p. 1). Metaphors in language help us to articulate abstract ideas in terms that are intelligible to others. The metaphors that we choose to use reflect our individual experiences and unique understandings of a particular concept. For this reason, educational researchers have investigated the metaphors and analogies that students and teachers use in classroom discourse, in order to better understand underlying conceptual structures.

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In his book, Pugh explores the various metaphors that have been used by cognitive psychologists and educational researchers over the years to explain their respective theories. In addition, Pugh develops some new metaphors to help the reader further understand the nuances of each learning theory presented in the book. In the author's words:

> This is not another "how to" book telling teachers, parents, or students all the things they should do. Rather, I hope to spark musings about the meaning and ramifications of each core metaphor. Finally, some metaphors raise existential questions about the nature of reality or the reality of an individual mind. I present these questions for you to contemplate, without getting too philosophical. (p. 3)

One of the basic tenants of metaphor theory is that multiple metaphors are necessary for understanding complex, abstract concepts. A single metaphor may highlight certain aspects of a given concept, while obscuring others. This is certainly true for the many metaphors presented in Pugh's book. In each chapter, he carefully explains the value that each metaphor adds to our understanding of each particular learning theory, recognizes its limitations, and articulates how the metaphors work together to create a more complete understanding of how people learn.

2 Contents of the Book

2.1 Behaviorism

Behaviorism is the theory that learners can be trained to engage in certain behaviors based on reward systems. In the book, Pugh explains how B.F. Skinner drew on the work of Charles Darwin to develop a model of *learning as natural selection*. Natural selection is the scientific theory that individuals in a population with certain traits will tend to survive and reproduce at greater rates than others in the population due to the interaction between their traits and their environment. Over time, this leads to changes in the frequencies of traits in the overall population.

In the metaphorical application to teaching and learning, teachers (and society in general) reinforce particular behaviors, which will "survive" while other behaviors "die." In the classroom, this can happen through a system of punishments and rewards, where certain behaviors are rewarded (e.g., sitting quietly or standing in line) while others are punished (e.g., throwing something at the teacher). Although this behaviorist model of teaching is somewhat antiquated, Pugh points out that it still provides insight into various aspects of our educational system. For example, the *No Child Left Behind* legislation rewarded schools for improving student test scores in math and reading. As a consequence, elementary schools now spend the majority of the school day on math and reading. Science, social studies, and the arts have been cut because there is no positive reinforcement for schools to invest resources in these areas.

One limitation to behaviorism and the natural selection metaphor is that it treats learning as a strictly rational process. It assumes that behavioral traits are solely determined by external factors, and that all students will behave the same way in response to punishments and rewards. This leaves no room for students (or schools) to decide how to respond to the environment.

2.2 Cognitivism

In the 1950s, the emerging fields of computer science and artificial intelligence inspired cognitivism, which employs the metaphor of *mind as a computer*. The cognitivism theory

contends that learning happens when information is stored in long-term memory, analogous to the hard drive on your computer. But before information can be stored in long-term memory, it must be processed through your working memory, which is like the RAM (random access memory) of your computer. The working memory can only store small amounts of information for short periods of time. If information is not quickly stored to long-term memory, it is lost like a phone number you forgot to write down.

The implication of this theory for instruction is that students can only handle a certain amount of information at any one time (known as Cognitive Load Theory). In particular, novices can only store a certain amount of new information. This theory of learning would advocate for reducing the cognitive load on students in order to help them retain a larger fraction of the content. Teachers must be aware of the cognitive load they are placing on students, which includes content and other information relevant to learning (germane load), as well as factors like being able to understand the requirements of the task (extraneous load).

In turn, experts are better able to store and retrieve information because they have built complex networks in their brains. These networks provide access to information in the same way the internet allows us to access information from many different computers. Information does not exist in isolation, but is linked to many other pieces of information and may be discovered through many different paths. The *mind as network* metaphor is more than just a heuristic; it is a literal understanding of how the brain builds neural connections. Novices, such as students, can build these networks through appropriate instruction and therefore build storage capacity. This theory of cognition argues that learning happens in the construction of these networks. Pedagogical strategies based on the mind as network theory allow for students to make many connections to new information, which could take the form of problem-based or interdisciplinary instruction.

2.3 Constructivism

The *mind as computer* is an important metaphor for understanding learning, but what would happen if computers functioned like the mind? Pugh explores this idea in a humorous story he calls *computer as mind*. Every time a student goes to access a paper he has written, he finds that the content has changed. The content is constantly updating as he reads different websites, or writes a paper for another class. This story illustrates an important limitation to the *mind as computer* metaphor; our minds are ever changing based on new things that we learn. Factual knowledge does not directly transfer into our long-term memory, but rather is filtered through a particular lens. This is the basis for the next metaphor, which is used to explain the constructivist learning theory: *mind as ecosystem*.

The *mind as ecosystem* metaphor was first introduced by Piaget and was expanded in the conceptual change theory of the 1980s. The basic idea behind constructivism is that we learn by integrating new ideas in existing conceptual frameworks. This is analogous to a new organism being introduced into an ecosystem. According to Pugh, one of three things can happen when a new organism is introduced into an ecosystem. The first possibility is that the new organism will die because it is not well-suited to a particular environment. Unfortunately, this is what happens to many new ideas that are presented in school science classes. They do not fit in a student's conceptual ecology and quickly die. The second possibility is that the organism is integrated into an ecosystem without major disruptions to the environment. This is rare, but it does happen. A new idea fits with a student's current understanding of the world and is integrated without issue.

The third possibility, that the new idea is an invasive species, is the most interesting. These are the ideas that completely upend a student's understanding of the world and cause them to undergo conceptual change. Like an invasive species that disrupts the entire ecosystem, these ideas can disrupt the framework that a student uses to understand the world. This disruption is a good thing; this is when deep learning is happening. Students come to science classes with many misconceptions that are difficult to dislodge. As teachers, we need to find ways to plant an "invasive species" that will cause them to rethink how they understand a particular concept. This is what Piaget called accommodation, and others have called conceptual change.

2.4 Socioculturalism

However, there are limits to the *mind as ecosystem* metaphor. One clear omission is an understanding of how culture and society influence our ability to accommodate a new idea into our conceptual ecology. The sociocultural theory addresses this gap and provides a complement to the more rational theories of learning described above. Pugh uses two metaphors to explain the sociocultural theory: *mind as cultural tools* and *mind as cockroach or panda bear*.

The *mind as cultural tools* metaphor was first developed by Leo Vygotsky. Vygotsky believed that we learn by using tools that help us to process and make sense of new information. The tools that we develop are based on the culture in which we live. The most obvious cultural tool that we have developed is language. The language that we speak (or do not speak; Pugh gives an example of a nonverbal individual) influences how we understand new ideas and how they are integrated into our conceptual ecology. Pugh emphasizes, "The nature and quality of our mental activity is dependent on the nature and quality of our mental tools" (p. 114). For example, the algorithms that you use to do simple arithmetic determine how quickly you can do mental computations.

From this perspective, innate intelligence is over-rated; what is often considered to be intelligence is a certain fluency with the cultural tools that have been adopted by a society. The implications of this for teaching are tremendous. Many of our students come from cultural backgrounds that emphasize and value ways of knowing that are not privileged in traditional school science classrooms. Rather than thinking of these students as deficient in some way, it is more productive to consider how their cultural tools help them understand new ideas. Learning is a process of enculturation; students learn science in part by learning the culture of science, including how to speak, write, and interact in ways that are acceptable to the scientific community.

The second chapter on socioculturalism focuses on situated learning, or the way that a particular social environment can influence learning. To help explain situated learning, Pugh introduces a metaphor of his own making: *learning as cockroach or panda bear*. Cockroaches are easily adaptable; they can survive in many different types of environments. The constructivist and cognitive learning theories discussed above are cockroach theories; they maintain that skills and knowledge are not highly dependent on the particular learning environments, but rather more focused on the individual.

In turn, the situated perspective is that student learning is more like a panda bear. Panda bears require a very particular environment for survival, including a large amount of space, a specific climate, and narrow range of altitudes. A biologist studying a population of pandas must consider all of these environmental factors in addition to the animal itself. The same is true for researchers who take the perspective of situated learning; a student's learning must be

studied in context. For example, to many people, the mathematics required for a trip to the grocery store looks quite different than the math that most people learn in school. Situated cognition explores how it is that we have adopted learning strategies and tools that are specific to these two different environments.

The situated perspective also provides an interesting take on the issue of knowledge transfer. In the constructivist and cognitive theories, researchers are often concerned with the degree to which students can transfer a particular skill or knowledge to a new domain (e.g., using algebra to solve a physics problem). But through the lens of situated cognition, these are two unique environments and we should not expect students to automatically transfer their skills. Instead, we need to train students to "crisscross" their knowledge by teaching them different ways to solve problems using multiple perspectives.

2.5 The Purpose of Learning

The final section of the book explores the purpose of learning, using the metaphors of *learning as the journey* and *learning as art*. Pugh uses the *learning as the journey* metaphor in contrast to *learning as the map*. As an example, he explains how reading a travel guide about rafting on the Colorado River does not provide the same experience as actually taking the trip yourself. No amount of reading can prepare one for the journey of discovering new knowledge.

In this metaphor, the map is the body of knowledge that has been accumulated by human civilization over time. This can be found in textbooks and didactic lectures. In turn, the journey is how students engage with these ideas in active ways and construct new knowledge. The map (prior knowledge) can provide the backdrop for new journeys (the discoveries); it is the starting place, not the finish line. One implication of this philosophy is that the traditional approach to education that emphasizes factual knowledge needs to be replaced with teaching strategies that give students experiences that lead to learning in a more authentic way.

For example, Pugh explains that Boy Scouts completing a Fly Fishing merit badge are required to tie knots, name five kinds of bait, read fishing regulations, etc. This is a very traditional approach to learning; a checklist is provided and if students complete each task on the list, then they get the merit badge. However, you can complete the merit badge without ever going fishing! This is analogous to many science classes that can be completed without ever engaging in the scientific process. Pugh suggests some revisions to the merit badge requirements, including (among others) the following: go fly fishing in a stream; go fly fishing in a river; go fly fishing with your grandpa; catch, photograph, and release at least four kinds of fish; go to a shop and talk fishing stories with the owner; learn proper first aid for getting a fly out of your ear. These activities help the scouts to not only better construct an overall understanding of the mechanics of fly fishing but also construct understanding of the culture of fly fishing.

In the last chapter, Pugh explores the metaphor of *learning as art*. "Just as great works of art can change the way we see and experience the world, so great disciplinary ideas can transform our everyday experience" (p. 157). In this book, Pugh has presented many different perspectives on learning, and each of these perspectives provides a different lens for us to understand how students learn in the classroom. Each metaphor/learning theory highlights a different aspect of the learning process. Individually, the metaphors cannot tell the entire story about how people learn, but taken together we have a more coherent understanding of cognition. The implication for instruction is that it is not enough to employ just one learning theory in practice; teachers need to have a firm understanding of each of these theories so that they can fluently move among them and design better, multifaceted, learning experiences for their students.

3 Conclusion

Computers, Cockroaches, and Ecosystems provides a concise and easy-to-read introduction to four major learning theories: behaviorism, cognitivism, constructivism, and socioculturalism. It is a practical and relevant guide for new and experienced teachers alike. Pugh helps the reader to understand each of the learning theories using examples drawn from his own personal experience, as well as case studies from the literature. The book is written in a conversational tone that is easily accessible and mostly free of jargon.

I would recommend using the book in a class for pre-service teachers, such as an educational psychology or science teaching methods course. Although the content is not explicitly about science education, there are many examples of science sprinkled throughout the book and students could be challenged to find their own examples in their practicum or field experiences. An additional audience would be experienced teachers, who may want an introduction to (or refresher on) learning theories. I plan to use portions of the text in professional development work that I am doing with college science faculty next year, who will benefit from a more nuanced understanding of learning theory and the implications these theories have for classroom instruction.

A final audience for this book may be students themselves. I can imagine using the book with undergraduate science majors in order to help them better understand their own learning. This could help students to develop metacognition skills and take greater responsibility for their education. If we want to move away from traditional science instruction, it is important for students to understand why our teaching strategies require them to be actively involved in the learning process. The teacher is no longer the source of information and the student the receptacle. The metaphors presented in this book could help students to see the relationship between particular teaching strategies and learning theories.

Compliance with Ethical Standards

Conflict of Interest The author declares no conflict of interest.