Teaching

Learning for Life

An Ecological Approach to Pedagogical Research

David B. Daniel[1] and Debra A. Poole[2]

[1]James Madison University and [2]Central Michigan University

ABSTRACT—*The trend to convert laboratory findings on the conditions associated with optimal memory into recommendations for teaching strategies and learning aids will harm students if findings fail to generalize to students' usual learning environments. Moreover, it is likely that pedagogies function differently for students with different degrees of background knowledge, time, and interest in the subject matter; that some support activities will prevent students from honing their ability learn from narrative material without guided learning; and that an overuse of learning aids will tax students' ability to use them effectively. We contrast two approaches to developing pedagogy—memory first and pedagogical ecology—and explain how the human factors approach of pedagogical ecology could be a more satisfying model for the scholarship of teaching and learning.*

In 1979, Uri Bronfenbrenner issued a statement that became the mantra for a generation of developmental psychologists: "In ecological research, the principal main effects are likely to be interactions" (p. 38). The beloved father of the bioecological model began by questioning the long-standing tradition of studying "the strange behavior of children in strange situations for the briefest possible period of time" (Bronfenbrenner, 1977, p. 513). Bronfenbrenner argued for an alternative by presenting numerous examples illustrating why researchers needed to observe people in the environments in which they lived. The key features that emerged from this endeavor—a multilevel conceptualization of the environment and reciprocal interactions among people and environments—are part of the world view that helps developmentalists understand change over time. More concretely, Bronfenbrenner's major contribution was the idea that interactions between people and their environments are so pervasive that researchers should anticipate them and build their research designs to find them.

Address correspondence to David B. Daniel, Psychology Department, James Madison University, Miller Hall, Room 1179, 91 East Grace Street, MSC 7704, Harrisonburg, VA 22807; e-mail: danieldb@jmu.edu.

Recently, we have become convinced that an ecological mindset would greatly benefit the scholarship of teaching and learning. Our primary concern is the growing popularity of *memory first* approaches to pedagogical research, approaches that may be aptly described as "the strange behavior of students in strange situations for the briefest possible period of time." To explore our concern, we first looked at medical resources to identify reasons why interventions that usually benefit people can cause harm under some circumstances, and we then mapped those concepts onto recent suggestions for improving undergraduate learning. This exercise helped us identify four reasons why main-effects–oriented research and premature recommendations about pedagogy might harm students. In this article, we review what we discovered from this exercise and propose a new perspective, which we are tentatively calling *pedagogical ecology*, that could become a bioecological model for the scholarship of learning and teaching. To explain how this approach differs from other ways of developing pedagogy, we will turn your eyes briefly toward outer space and back into your living room, describe a failed experiment that illustrates the core problem with memory-based thinking about student performance, and invite you to join our efforts to create a more satisfying field of research on student learning.

HOW EFFORTS TO IMPROVE GRADES MIGHT HARM STUDENTS

In *Survival of the Sickest* (Moalem, 2007), Dr. Sharon Moalem described a disturbing case of good intentions gone bad: 35 years ago, doctors in New Zealand routinely injected Maori babies with iron supplements to remedy what they assumed was a deficient diet, only to find that treated babies were seven times as likely to contract potentially deadly infections. Unfortunately, it is not uncommon for nutritional supplements that benefit people under some circumstances to fail miserably in specific environments (in this case, because iron feeds bacteria), when prescribed for individuals with specific characteristics (such as when vitamin D worsens hypercalcemia; Cunningham, 2004), when supplements mask conditions that would otherwise be identified and remedied (as when folate masks a B-12 deficiency; Rothenberg, 1999), or when taken in excess (with fat-soluble vitamins being especially likely to cause complications). Even with only a small database on learning in classroom settings, it is clear that some popular recommendations for improving students' grades have the potential to cause harm for the same reasons vitamin supplements sometimes cause harm. Consider the following examples.

1. *Context effects: Recommendations that improve learning in one environment may have no effect—or even impair performance—in others*. An example of this problem is research on quizzing. Although there is little doubt that frequent quizzing can improve subsequent test performance in controlled conditions (Roediger & Karpicke, 2006a, 2006b), students have a bank vault of techniques for circumventing what instructors have in mind when they assign independent quizzes, such as looking up answers in the book during the quiz (sometimes instead of actually reading the book), working in groups, and repeatedly taking quizzes in an attempt to learn directly from the feedback in lieu of reading assigned materials (Brothen & Wambach, 2001, 2004). In a review of feedback studies, students performed worse when they were given the answers to practice questions (without having to answer the questions first) than they did when they were given no study aid at all (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991). As a result, independent quizzes do not improve classroom performance without the relevant controls present in more structured environments (Daniel & Broida, 2004).

Although misuses of learning aids, like misuses of medications, may be easy to remedy, there will be more substantive challenges if learning aids that function well in the laboratory interfere with course goals related to conceptual integration over the course of an entire semester. The problem, of course, is that brief laboratory studies with small amounts of target material in tightly controlled settings will rarely tell us when this is the case.

2. *Individual differences: Enrichment activities that help one segment of the student population could impair the achievement of other segments*. Motivated students probably add activities assigned by professors to the basic task of mastering their book, but students who are slow readers and those who work many hours per week may save time by using pedagogical devices in ways that consolidate knowledge for a restricted subset of information. For example, signaling devices such as headings and marginal inserts can improve learning (e.g., Lorch, 1989), but in one study researchers found that sentences previewing upcoming information and signaling back to previously read material actually impaired how much students learned about unsignaled information (Wyman, Dietzer, Barry, Munson, & Glover, 1990; see also Nevid & Lampmann, 2003). When used in the college classroom, self-reported usage of text-embedded signaling devices was neutrally to negatively associated with exam performance (Gurung & Daniel, 2005). These results raise concern that some students rely on signals to guide reading and skim nonsignaled information. Clearly, evidence that an enrichment activity enhances learning in the laboratory is not evidence it will do so for all ability and motivational levels when tested in students' usual learning environments.

3. *Masking a deficiency that would otherwise be remedied: Guided learning activities could prevent students from honing their ability to learn from narrative material*. There is little doubt that some videos and tools on a course Web site can improve conceptual understanding, long-term recall, and a course's "fun factor." But some support activities provide mechanisms for learning that are not typically available when students enter careers. We wonder whether overuse of pedagogical aids will compromise students' long-term success by preventing them from learning how to master information in documents without guided learning. For example, textbook publishers respond to pressure from potential adopters by developing numerous learning aids, but no one discusses how the academy as a whole should fade the use of these aids, so students learn to monitor and direct their own learning.

4. *Overdosing errors: A diverse set of learning aids could exceed students' ability to manage demands on their time, particularly when every course has numerous and different requirements*. As anyone who has waded through colleagues' syllabi during promotion reviews knows, college classes have gotten more and more complicated, as have demands upon the students in them. In addition to class periods, a textbook, and a study guide, students are often expected to log into course management systems to retrieve announcements and supplementary readings, take quizzes, participate in discussions, and submit assignments—and these sites often connect to publisher-provided content that varies tremendously in format and ease of use. Meanwhile, the number of pedagogical aids in text books continues to grow (Marek, Griggs, & Christopher, 2002; Weiten & Wight, 1992). And, counter to intuition, reported use of these tools has revealed low to negative correlations with exam performance (Gurung, 2003, 2004). Although these correlational findings could be due to any number of factors, there is evidence that students pick and choose among tools when many are offered, often preferring the most efficient over the most effective (Daniel, Woody, & Gibson, 2007). It is clear that the sheer complexity of the environments we are creating for students may pose a serious threat to their motivation to engage in learning. More important, the strategies they adopt to handle this environment may not be the best for building conceptual knowledge that readily transfers to new situations.

Of course, issues like these are unlikely to be remedied by experiments that test the ability of a single learning aid to improve a single outcome (usually memory for a constrained set of material) when presented to a relatively homogenous group of students in a specific environment. The possibility that conclusions drawn from such research might do harm is apparent to anyone who has taken a moment to think about the problem. For example, what if guided learning activities in an introductory psychology class improved final exam performance at the expense of reducing the number of highly prepared students who ultimately majored in psychology? This could occur if instructors focus so much on mastering terms that students lose sight of the exciting problems psychology is trying to solve or if grade inflation leads the best students to feel less enthusiastic about choosing our field (interaction). Other possibilities spring readily to mind. In a recent study of children's memory, for instance, issuing reminders about a complex event improved memory shortly after the event, but not many months later (London, Bruck, & Melnyk, in press). What if frequent quizzing reinforced instructors for quizzing but failed to improve the conceptual integration that builds long-term, flexible knowledge (interaction)? A field that grappled with these problems would need to consider the multiple ecological levels of students' environments and also be deeply concerned about how pedagogical tools impact knowledge use and motivation for new learning over long periods of time. Pedagogical ecology seems an appropriate term for a field that would keep these things in mind.

LESSONS FROM NASA, DON NORMAN, AND *BLUE'S CLUES*

When we first began thinking about pedagogical ecology, we envisioned a field that would become the "human factors" of teaching and learning. Instead of viewing students as input–output devices with memory systems in between, we wanted to acknowledge that people actively choose how to spend their time and where to direct their attention. But also, students confront learning environments and opportunities with different conceptual models that influence how they interpret information and how they interact with technology. Because our training as developmental psychologists did not prepare us to attack these issues, our next step was to find a crash course in human factors.

It was not hard to decide where to spend a few days of study: NASA's Web site, Don Norman's *The Design of Everyday Things* (2002), and the history of *Blues Clues*. NASA was an obvious choice. After all, these scientists had put a dozen people on the moon, whereas we were having trouble getting students to walk from the residence halls to the psychology building. Don Norman, an eminent cognitive psychologist, has served as vice president of Apple Computer's Advanced Technology Group, investigated industrial accidents (the real-world equivalent of getting an "F"), and generated a framework that helps designers make things that work. And *Blues Clues* works. The originators of this children's television show did what every academic wants to do: They threw convention to the wind and let empirical evidence show them how their target audience learns.

We started with NASA's Human Factors 101, an online tutorial that introduces the fields of human performance, technology interface design, and human–computer interaction (National Aeronautics and Space Administration, 2003). With NASA-like precision, the first paragraph of the first lesson contained the concept we were looking for: "Through observation, monitoring, and analysis, we are better able to predict and enable human performance." Traditional pedagogical research has a lot of analysis—we give students information in a certain format and analyze what they remember. But where is the observation? Where is the monitoring? Where is Bronfenbrenner's notion of watching people do what we are interesting in them doing in the places they do it? A human factors of teaching and learning must include all three of these activities.

Don Norman's book explains what can be accomplished by combining observation, monitoring, and analysis with a framework for thinking about human performance. He described why it is important to understand the conceptual models people bring to tasks, why feedback is important, how to design with constraints, and how to harness "perceived affordances." We learned about forcing functions, designing for individuality, and what goes wrong when designers think about the device they are trying to make rather than the task people are trying to perform. Clearly, the books, Web sites, and learning activities in our students' lives are everyday things, and their design should reflect known principles for designing everyday things.

Next, we took a short cut and revisited Malcolm Gladwell's synopsis of all that went well with *Blue's Clues* (Gladwell, 2002). For the uninitiated, *Blue's Clues* is a children's show featuring a dog (Blue) who helps the audience answer one question each episode from three clues. Unlike *Sesame Street*, which was built on the assumption that shows constructed from many short segments would be most compatible with children's short attention spans, the *Blue's Clues* originators believed that children would happily sit still for an entire show if the narrative structure was compatible with how they organized experiences. Each episode of *Blue's Clues* was extensively tested on children's panels to ensure that the opening clue was "strong" (i.e., was answered by the majority of children), that the order of clues was suspenseful (i.e., led to a broad range of guesses early in the show and narrower thinking later in the show), and that scripts were just complex enough to promote deeper levels of comprehension with repeated exposure (each *Blue's Clues* episode aired on 5 consecutive days). What appealed to us about this example is that the *Blue's Clues* designers played to children's strengths (rather than remediating perceived deficiencies) to develop a structure for writing and testing segments that developed conceptual understanding.

By the end of a week of study, we were struck by one take-home message: Designers are usually incapable of predicting how others will fail in the face of their products, so "there is no substitute for interaction with and study of actual users of a proposed design" (Norman, 2002, p. 155). We were convinced that these principles were just as true if the designers were creating interventions to improve student learning as they were for the team who designed the (usually incomprehensible) procedure for programming the VCR in your living room. We were convinced because a failed experiment and a foray into e-books had shown us this was true.

FAILURES AND INTERESTING OBSERVATIONS

Many years ago, one of us (Debra A. Poole) learned how foolish it is to assume you already know what the problem is when you set out to improve student learning. She knew that students who failed the first or second biweekly exam in a large-lecture introductory psychology class were unlikely to earn a final grade of C or better, so she organized an intervention to provide an academically oriented conference for every student who failed an early exam. During these individual sessions, a graduate assistant asked students to describe why they thought they had failed and explained the three types of questions that appeared on each exam. The presentation that followed included tips for mastering information and the Cornell method of note taking. At the end of each conference, students received a sheet that listed the habits of successful students, such as distributing study time and using the study guide to prepare for exams.

Results were disappointing. In comparison with the results from matched students from earlier classes with the same instructor, individual academically oriented conferences did nothing to improve the grades of students at risk of failure (although the intervention did alert students to the withdrawal deadline). The program failed despite the fact that students liked it and thought it should be available to anyone who was interested. Why? In a nutshell, students were not failing because they were having trouble mastering the material, because they thought the class was boring, or because they thought the instructor was doing a poor job. They did not need better ways to learn terms or suggestions about note taking. They were not butting their heads against the limits of human memory. Instead, failing students readily volunteered that they did not own the book, were not reading the book, or did not own the study guide (a required book for class that provided some of the test questions). Many were not regularly attending classes. By their own admission, some of these students were not engaged in college because they were working through social and emotional issues that come with sudden freedom and a desire to focus on peers; others were confronting one of many personal issues that pushed college to the bottom of the things-to-do list. These students needed help, but they did not need high-school level study tips. Deb had misconstrued the problem.

A paper reporting this study was rejected because (a) the program didn't work, and (b) everyone already knew that academically oriented conferences didn't work. Ironically, Deb had reviewed studies supporting the second point in her introduction—she just found it hard to believe that conclusion until she saw the evidence with her own eyes.

Once you begin observing students, you simply cannot hold on to the hope that anyone can ask the right questions about teaching and learning without watching students perform tasks in the environments in which they usually perform those tasks. In a recent study on e-books, for example, one of us (David B. Daniel) had students read text for a subsequent quiz in a number of conditions, including from a computer screen. The learning outcomes were fairly equivalent across conditions in the lab. However, several students in the e-book condition had to be inhibited by the experimenter from checking their e-mail and engaging in other Web-based activities. To explore this behavior further, he asked students who had used or were currently using e-books to report back on how they used them outside of the lab. With few exceptions, students in this pilot group reported that they messaged and checked social networking sites while reading (students also did this while reading textbooks, but at lower rates and not in the same medium). Clearly, just as cockpits are designed to reduce errors, effective pedagogy should be designed to incorporate knowledge of users' typical behaviors in the context and conditions in which tasks are performed.

MEMORY FIRST VERSUS PEDAGOGICAL ECOLOGY

How does pedagogical ecology differ from the way we had been thinking about student learning (i.e., memory first)? Table 1 summarizes the answer. First and foremost, a memory-first approach has an almost exclusive focus on the amount of material students learn, with sophisticated versions of this approach looking at how students apply knowledge to solve new problems (e.g., Bjork, 2006). In contrast, pedagogical ecology is an interdisciplinary enterprise that incorporates ideas from education, school psychology, human factors, and other disciplines. This approach recognizes that many issues impact student learning, including issues of personal identity, how values influence the way students spend time, and cohort-specific factors related to the material environment (such as the technologies students use to communicate in their everyday lives). For example, school psychologists already know how to motivate students to finish work sheets by interspersing easy items into more difficult items using just the right ratio and spacing (e.g., Rhymer & Morgan, 2005), yet concern about motivating students is largely absent from studies of guided learning activities.

Second, the memory-first approach does not begin with observations to define the nature of the problem. If students are not learning, instructors assume the reason has something to do with basic memory issues. In contrast, pedagogical ecology believes in observing students in their classrooms and living environments to determine the characteristics of people who are failing and why they are failing.

Third, the memory-first approach proceeds as if resources for research and development were limitless. If there were true,

TABLE 1
Approaches to Pedagogical Research: Major Emphases of Memory First Versus Pedagogical Ecology

Item	Memory first	Pedagogical ecology
Intellectual underpinnings	Focused primarily on concepts from the memory literature	Interdisciplinary
The role of observation	Begins with theory to identify the nature of the problem	Values observation of students in context to identify the nature of the problem
Assumptions about resources	Proceeds as if resources were limitless	Assumes resources are tight
Focus on interactions	Limited; heavy focus on laboratory research that can isolate variables to minimize complexity	Identifying interactions is a primary goal; integrates the complexity of context into research designs

there would be time to build knowledge about student learning by starting with simple memory studies and working toward demonstrations of teaching techniques in more complex environments. According to this approach, laboratory memory studies are an initial step toward larger, more ecologically valid, studies. Pedagogical ecology, however, recognizes that resources are tight, so interventions should target issues that will produce the greatest improvements in learning. For example, if students are failing primarily because they are not reading on their own time, then tests of techniques that engage students are more important than tests of techniques that lead to small improvements in the amount of lecture material they master.

Finally, the memory-first approach has a limited focus on interactions. When researchers from this approach discuss interactions, they usually talk about memory differences at two points in time or at two levels of student performance. In contrast, pedagogical ecology is especially interested in interactions that connect different educational goals and those that cross multiple levels of the ecological system. For example, pedagogical ecology is interested in anticipating how procedures designed with a narrow goal in mind, such as improving mastery of key terms, might sabotage other goals, such as students' ability to learn on their own in the future.

It is easy to anticipate what the critics of pedagogical ecology will say: "This term is just a newfangled way of saying everything matters, which everybody already knows". According to this critique, studying memory for material in constrained environments is a necessary first step, one that helps us understand the basic architecture of the learning system before we look at how that architecture functions in different environments. There is some truth to this. But our point is that research designed to reveal basic mental architectures should not be confused with research designed to identify what is best for students. The former is cognitive psychology; the latter is pedagogical ecology.

CONCLUSIONS

In sum, we are advocating for a new approach to pedagogical research, called pedagogical ecology, that will become the human factors of research on student learning. Pedagogical research from an ecological perspective will ask how students behave with learning systems and what that tells us about how to design more effective learning systems and strategies. The research teams that assemble to do this work will have a firm grounding in cognitive psychology but also be versed in relevant literatures in education, school psychology, and human factors—literatures that speak to motivational issues and how the design of everyday things can be improved to enhance performance and reduce user errors. Critical concepts in the design of everyday things, such as knowing when to stop development and avoiding proliferation of design features, will be applied to pedagogical endeavors just as they should be applied to designing our cellphone icons and microwave doors.

Pedagogical ecology will bridge two fields that currently suffer from different limitations. Research from the tradition of cognitive psychology identifies core principles that constrain how people learn, but the recommendations for teaching that have emerged from this tradition do not always work. Alternatively, classroom-based research has limited disciplinary prestige, partly because these endeavors are not focused on revealing fundamental principles that are the currency of science. The goal of an ecological approach to pedagogical research is to generate a database on student learning that will reveal what we really want to know, which is how the fundamental mental architecture that supports learning interacts with other aspects of individuality and environments to produce meaningful differences in human performance. Only with this knowledge will we know how to teach.

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