Ten Core Principles for Designing Effective Learning Environments: Insights from Brain Research and Pedagogical Theory

by Judith V. Boettcher

Research findings into how our brains work (Bransford, Brown, and Cocking 2000; Damasio 1999; Pinker 1997) are stimulating a re-examination of traditional principles of designing teaching and learning experiences. Insights from this research are not only helping to deepen our understanding of traditional core learning principles, but they are also providing practical guidance on how to design learning experiences for our new high technology environments.

The following ten learning principles illustrate how recent research integrated with traditional principles of pedagogy and instructional design can enrich our understanding of thinking and learning processes. The principles outlined here can serve as a guide to the design of learning experiences in both online environments and traditional campus classrooms.

Core Learning Principle #1: Every Structured Learning Experience Has Four Elements with the Learner at the Center

The first core learning principle offers a framework that helps simplify the complexity of instructional design by distinguishing the role of each element in the learning experience. This framework (LeMKE) has four elements—the Learner, the Mentor/faculty member, the Knowledge, and the Environment (Boettcher 2003). This principle can be captured by envisioning a learning experience featuring the *learner* "on stage" actively learning under the direction of the *mentor/faculty* member using a set of resources containing the *knowledge/ content/skills* to be learned within an *environment.*

There are many variations of this framework, of course, but all instructional experiences have these four elements. The first element, the learner, may be an individual student or a group of students. In the case of collaborative and group learning activities, for example, multiple learners may well be on stage at the same time, but every learner experiences the learning somewhat differently. The second element is the mentor/faculty member who provides instruction and support to the learner. The mentor/faculty member may be physically present on stage, may remain in the wings directing the learner, or may only be present implicitly by virtue of having designed the instructional event. This element may also be an inanimate learning object such as a text or video component that provides instructions and guidance from the faculty member.

The third element is the knowledge, the content, or the problem that is the focus of the instructional experience. In instructional design terms, the knowledge component is the answer to the question, "What is the knowledge, what is the skill, what is the attitude that the instructional event is intended to facilitate in the student?" In a geology course, for example, the knowledge or skill may involve student proficiency in identifying distinctive rock formations in order to reconstruct the natural history of a particular setting. The fourth element, the environment, is determined by answering the question, "*When* will the event take place, with *whom* and *where* and *with what resources*?" For example, the result of an instructional experience might be for a student to identify the different types of sedimentary rocks, the location(s) they might be found, and the process required to find them. This might be done in a virtual environment where the student can examine a rock in three dimensions, or the student may be tasked to collect real specimens in the field, photograph them, and contribute these specimens and photographs to a collection using mobile handheld photography technology. Another task providing opportunities for personalizing and customizing learning might be creating a Web site, a film, or other multimedia resource.

Whatever the scenario, it is the student who is at the center of the learning experience: The student is on stage, guided by the task design created by the faculty member, accessing whatever resources might be needed, and acquiring useful knowledge from the experience. This fundamental design framework serves as a context for the principles that follow.

Core Learning Principle #2: Every Learning Experience Includes the Environment in which the Learner Interacts

Every learning experience occurs within an environment in which the learner interacts with the content, knowledge, skill, or expert. The environment might be simple—for example, one learner with one resource at home, work, or some other community space (Oldenburg 1999). The environment might be complex, such as several learners with many resources in a classroom, library, media center, or café. Another type of environment might be a synchronous virtual meeting place, such as when several students collaborate online with many resources in different locations. The faculty member's involvement and presence can vary in any of these environments.

The question to be anticipated by faculty when they are designing a set of course experiences is where, when, with whom, and with what resources will any particular instructional event be likely to occur, and what are the expected outcomes? Will this experience be a small group meeting planning a team project using a synchronous meeting tool? Will this event be an experience where a team of two students interviews restaurant workers about their knowledge of public health regulations? Or will this experience be an individual experience where the student is working through a complex simulation? In designing an effective learning environment, faculty will face a range of options as they seek to find the best combination of learning experiences available for their students.

Whatever the specific environment, a well-planned course provides a variety of interaction choices for students. For example, a well-planned course balances three levels of interaction: faculty-to-student, student-to-student, and student-to-resources. Additionally, a well-planned course balances three types of activities: individual activities, small group activities, and large group activities. By ensuring multiple channels of communication, engagement, and collaboration within the design of a course, faculty members provide a richly textured environment that can accommodate a full range of student needs and learning styles.

Core Learning Principle #3: We Shape Our Tools and Our Tools Shape Us

The fact that we shape our tools and our tools shape us may appear at first to be a strange learning principle. Yet this principle arises from the fact that learning occurs only within a context—that is, through an interaction between a person and a learning environment, as noted above. This contextual feature of learning has its roots in the theories of Dewey (1933) and Vygotsky (1962), and it continues to inform the more recent work of Damasio (1999) and Bransford et al. (2000). The environment as envisioned in these theories includes all the tools, resources, and people that are part of any particular learning experience (Daniels 2001).

Tools make a difference in any learning environment. In previous generations, the faculty member lectured, the students took notes, and the learning process unfolded within a relatively limited and discrete environment of tools and technologies. The learning environment is considerably more complex today, including a network in which all students and faculty have access to powerful digital tools for communication and research. The first wave of laptop universities rolled out in the mid-1990s and were followed quickly by a wave of wireless and Web-enabled cell phones, and we are now in the middle of a third wave of mobile and hand-held digital tools. A learning environment in which all learners and faculty have their own personal laptop computer and other mobile tools such as iPods and PDAs transforms teaching and learning experiences. Meanwhile, students have discovered the community-building and networking power of instant messaging, discussion boards, online forums, blogs, and wikis while still occasionally using e-mail. These tools are dramatically changing the communication patterns and relationships between learners and the faculty.

While such changes are manifold, they generally entail a realignment of faculty roles and student learning activities. In an environment infused with these tools, the faculty member moves from the center of the class communication pattern—as is common in the traditional transmission mode of learning—to the periphery. In turn, the anywhere/anytime access to communication tools makes it easy for students to go outside the organized course structure and content. Another significant design impact of these tools is the ease by which students can customize their own learning experiences as the content boundaries of a course dissolve. Readily available mobile tools now support information access and flow in real time, enabling current events, global perspectives, and far-flung resources to be brought into immediate and fresh relief. Every statement by a faculty member is subject to challenge, addition, or confirmation from a student's Google search. Many teachers have been surprised by the shifts in learning dynamics and relationships created by these tools; at the same time, many teachers are now enthusiastically embracing these changes as they recognize the many benefits of learners becoming more engaged and active in their learning.

Core Learning Principle #4: Faculty are the Directors of the Learning Experience

In accordance with recent scholarly trends, the LeMKE framework places learners center stage; however, it also affirms the critical role of the mentor/faculty member. The role of the faculty is to design and structure the course experiences, direct and support learners through the instructional events, and assess the learner outcomes. In theater terms, the faculty member is the director of the learning experience, not the "sage on the stage" who transmits knowledge. When the faculty member is acting as the "sage," it is the faculty member who is reaping the benefits of working with the content, structuring the content, and communicating the content. One goal in designing effective and efficient learning environments is to get the students to work this intensively with the content. Strategies that support this shift in perspective include having the students moderate discussion forums, prepare concept summaries and examples for other students, and assume greater responsibility as front line moderators for the course. A faculty member need not be present at 2:00 p.m. on a Saturday afternoon for monitoring questions and discussions; however, through online forms of communication students can support other students, either formally or informally, almost 24/7.

Furthermore, the role of technology in the learning environment allows for the teaching functions of the faculty member to be redistributed in other ways as well. In particular, all teaching functions no longer need to be embodied in one person but can be assumed by various members of instructional teams. During the development process, for example, the design and development of online courses may be done by an instructional designer collaborating with a senior faculty member. During course delivery another faculty member may take over the functions of directing, supporting, and assessing the learning of students. This greater flexibility in the distribution of teaching functions is accompanied by the same freedom from time and space constraints that students experience. Faculty can monitor student learning and facilitate discussions from anywhere there is a high bandwidth wireless connection.

The point is not that faculty will be less involved in classes, but that these new instructional options will provide faculty with more effective ways to leverage their expertise. Using technology to encourage peer-to-peer learning enables students to make better use of the faculty member as a source of specialized guidance and feedback. Likewise, one of the more important ripple effects of a course design incorporating an instructional team is that the faculty member has more time to mentor the learning processes of students. Less time is spent on administrative and technical issues, and more time is spent on the formation of thought.

Core Learning Principle #5: Learners Bring Their Own Personalized Knowledge, Skills, and Attitudes to the Learning Experience

Learning Principle Five focuses on the learner as an individual. Most courses are designed with a set of core concepts and knowledge for the students to learn; however, if we do our job of teaching well, our students integrate those new core concepts into their unique knowledge structures, richly expanding their useful knowledge. Each of our learners' brains is as unique as an individual's fingerprints and DNA, and our students' knowledge bases inevitably become more individualized over time. This is a highly desirable

outcome as our goal is not to develop standardized brains, but richly differentiated, creative brains with shared experiences.

The process of designing learning environments includes anticipating the existing knowledge structure of the learners' brains at the outset of a course. Do students come with a "jungle" brain, replete with intricate patterns of knowledge about art, biology, electricity, and communications, or do they bring a brain characterized by small, unrelated bits and pieces of information resembling scraggly weeds, scrawny bushes, or a sparse, bare tundra? How rich are their mental patterns and images?

A related educational principle counsels teachers to build on what students already know, and recent memory research is confirming this principle by demonstrating the impact of students' existing mental models on incoming knowledge (Damasio 1999). The process of learning might be defined as the process of our brain finding receptor nodes for bits of new information and then arranging that information into a useful mental model. When learners encounter not just one concept but a confluence of new and unfamiliar discrete items in rapid succession, they must work to attach this incoming knowledge to existing nodes and patterns. The more concepts, the more patterns, and the more interconnectedness in the brain structure, the more receptor nodes exist. For cognitive researchers as well as instructors, this principle applies: "The more you know, the more you can know."

One of the ways faculty can tap into students' existing knowledge or mental model is simply to begin a learning experience by asking students about what they already know—or think they know. In traditional classrooms instructors have typically solicited this information at the beginning of a course through in-class discussions or through informal writing assignments that ask students to discuss their personal interests, academic goals, and educational background. In turn, currently available technological tools provide instructors with a wider range of avenues for gaining this valuable information about their students. Some of the tools that are helpful for this purpose include discussion boards, student response systems, and online testing modules that assess current skill sets as well as more complex forms of knowledge. For example, an English instructor can design an online test that targets specific areas of grammatical usage in order to assess student proficiencies during the first week of a freshman writing course. Likewise, a history instructor can require newly enrolled students to share their knowledge about the U.S. Civil War on an online discussion board and plan subsequent course modules and assignments accordingly. By knowing what students already know at the outset of a course, faculty can design more effective learning experiences that facilitate the growth of that knowledge over time.

Core Learning Principle #6: Every Learner Has a Zone of Proximal Development That Defines the Space That a Learner is Ready to Develop into Useful Knowledge

Knowing the state of a learner's knowledge structure helps to identify a learner's zone of proximal development. According to Vygotsky, a student's zone of proximal development (ZPD) 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. (1978, 86)

More succinctly, the ZPD defines the space that a learner is ready to develop into useful knowledge. This concept is similar to the traditional readiness principle in pedagogical scholarship (Bruner 1963; Knowles et al. 1998), but it is enhanced by its focus on the individual and encourages greater specificity regarding what sort of knowledge and concepts a student might be ready to learn at any one time.

Vygotsky's concept of ZPD not only highlights the importance of preliminary assessments of student knowledge; it also suggests that the window of learning opportunity for any individual student may be smaller

than what we might expect. When students say they are totally lost, they are probably expressing the feeling of being outside their zone. When students sit back and obviously disengage, it means they have probably lost the link, the relationship of one idea to the other. When this happens in a group situation or in a discussion board, the class culture needs to support the student asking a question so that he or she can get "linked" back up again. Otherwise the time will probably be lost to the learner and the learner may disengage even further.

The concept of this zone thus presents a significant challenge for faculty who want to maintain effective learning. How do faculty maintain an accurate sense of a learner's ZPD throughout the duration of a course? What are the elements of the learning community that allow the mentor to check in with each learner on a regular basis? What elements support a student's comfort level in asking questions?

This ZPD principle emphasizes the need for faculty to be alert to their students' state of understanding and capabilities on a continuing basis. This principle encourages embedding feedback and demonstrations from students earlier and more consistently throughout a course experience. Student questions, comments, participation, and outputs are means of determining more precisely the progress or state of concept development in students. Here, too, technology can play a vital role in addressing this challenge, whether through student discussion forums that solicit such information, periodic mentoring with individual students via chat, or more formalized online quizzes that assess student retention and comprehension of course material at smaller intervals.

Core Principle #7: Concepts are Not Words; Concepts are Organized and Intricate Knowledge Clusters

This principle, again from Vygotsky, is simple but profound. Concept formation is not a one-time event; rather, it is a series of intellectual operations including the centering of attention, abstracting, synthesizing, and symbolizing (Vygotsky 1962). Freeman similarly describes the assimilation of meaning as a process of "successive approximations" (2000, 15). What does this mean for designing learning experiences and courses?

When faced with a new field or discipline, students typically focus on learning the vocabulary of a discipline, but this activity is often done in isolation from an understanding of the concepts that give the words meaning. Without the underlying concepts, words are akin to isolated weeds and seeds likely to be blown away by the winds of time, usually mere hours after an exam.

A popular new teaching and learning theory advocates making students' thinking visible (Collins, Brown, and Holum 1991; Bransford, Brown, and Cocking 2000). Making thinking visible requires students to create, talk, write, explain, analyze, judge, report, and inquire. These types of activities make it clear to students themselves, to the faculty, and to fellow learners what students know or do not know, what they are puzzled about, and what they might be curious about with regard to the course material. Such activities stimulate the student's growth from concept awareness to concept acquisition, building in that series of intellectual operations that Vygotsky believes is required for concept acquisition.

Discussion forums, blogging, journals, and small group work are all excellent strategies for allowing learners to enlarge their mental models, to clarify concepts, and to establish meaningful links and relationships. Online tools are particularly valuable in this context because they provide a public forum in which the cumulative, step-by-step process of concept formation, refinement, application, and revision is fully visible to student peers as well as their mentors. By providing a comprehensive record of how concepts take form through multiple clusters of knowledge, such media can promote more complex and lasting retention of course material among students.

Core Learning Principle #8: All Learners Do Not Need to Learn All Course Content; All Learners Do Need to Learn the Core Concepts

This core learning principle focuses on one of the four key elements of the LeMKE framework: the content, knowledge, or skills that are the focus of the learning experiences. This learning principle highlights the distinction between the course content that is the means of learning and the core concepts to be acquired and developed by individual students. All content is not equal; only a portion of the content of any course is core concept knowledge, and the remaining content arises through increasingly individualized domains of application, practice, and skill acquisition by the learners.

Imagine the course content as a pie with concentric circles (Figure 1). The innermost layer represents the core concepts; the second layer, the initial application of core concepts by students to solve simple problems; the third, the application of core concepts by students to solve more complex or novel problems; and the fourth, the application of core concepts by students in unique contexts of their own choosing. The goal for all students is mastering a slightly off-center slice of the pie that includes the whole of the core concepts. The dotted lines indicate the slice of the course content that one student might master. As students develop expertise at each level of course content, they increasingly direct and customize their learning according to their own respective needs and priorities.

How can we provide this level of content flexibility and customization? The course Web sites used in blended and online learning environments enable linking to an expanded set of resources to support a wide range of problem analysis and customized experiences. No longer is the choice and availability of content circumscribed by the size or cost of a textbook. If encouraged, students will naturally gravitate to those materials and experiences that match their zones of personal proximal development. This means that designing a course includes providing access to a rich database of content and experiences. These databases of content and their integration into courses may need to evolve over time, but the principle is clear. Additionally, students need to be encouraged to develop metacognitive awareness of how they learn and what strategies and materials work for them. Faculty can achieve this goal by designing assignments that incorporate discussion and dialogue about how and why students process information and "come to know" what they know.

Core Learning Principle #9: Different Instruction is Required for Different Learning Outcomes

Robert Gagne, widely considered as the father of the discipline of instructional design, observed in *Conditions of Learning* (1965) that all instruction is not equal and that different types of instruction are required for different learning outcomes. Though not a groundbreaking concept today, the idea was quite novel in 1965.

What this principle means is that *what* a faculty member *does* makes a difference in what students *do*, in what students *learn*, and in what concepts students may or may not *develop*. This principle also reinforces the instructional design practice of planning student assessments simultaneously with the planning of instructional experiences and of embedding assessments within instructional events. This principle encourages us to answer the instructional design question of what knowledge, skills, and attitudes you want your students to develop and grow and then to design the teaching and learning events to accomplish those goals and determine what evidence will illustrate student accomplishments.

An example of this principle is the gradual reintegration of apprenticeships, internships, and complex problem-solving simulations into teaching and learning experiences. If the desired outcome is for students to be great chefs, they probably need to cook; if the desired set of skills is becoming entrepreneurs, students probably need to serve as apprentices in an internship environment or at least practice entrepreneurial activities. This principle is also at work with pilot training on simulators and students practicing lab techniques in a model environment. As faculty design their courses, they should ensure that they have explicitly defined the outcomes they seek to reach and that the learning experiences consistently support and assess these outcomes.

Core Learning Principle #10: Everything Else Being Equal, More Time-on-Task Equals More Learning

This principle has very traditional roots. It is basically the time-on-task principle. This simply means that as students spend more time interacting with information and practicing skills, the more proficient, accomplished, and confident they will become. Time-on-task helps students to make the knowledge their own. Learning is intrinsically rewarding and enjoyable. If we design great experiences, students will spend more time interacting with the course content and developing more complex, networked knowledge structures and efficient behaviors.

As directors of instructional events, faculty can encourage time-on-task by searching out and identifying well-structured materials that assist in concept formation, practice, and problem-solving. This includes identifying engaging, inviting, and stimulating content at the right zone of proximal development. As matching content and practice to each student's zone of proximal development is still a very inexact science at this time, the best way of ensuring a match is for the set of course materials and course experiences to be rich and diverse. As students develop more metacognitive awareness they will also naturally seek out and identify the types of resources and experiences that work for them.

A corollary of the time-on-task principle is that learning can be more efficient if we organize information into chunks. In today's virtual media environments, simulations, animations, and living worlds such as *SimCity* are powerful "learning chunkers." Chunking is just one reason games and role-playing scenarios are popular and valuable. Other valuable features of games and simulations are their unpredictability, their interactive qualities, and their infinite variety. Canned, predictable, and static learning resources such as books, preprogrammed tutorials, and linear video experiences are less interesting and less engaging. The more dynamic and interactive the learning experience, the more likely students will invest greater amounts of time in the learning process.

Conclusion

Current research about how students learn is illuminating the processes involved in teaching and learning. Insights gained from this research and integrated with traditional learning principles can help guide our design of learning environments so that both teaching and learning can be more efficient and effective.

One major insight contributing to these principles is the uniqueness of each brain in its structure and its accumulated experiences. We each do experience and remember events just a little differently. This richness of perspective and worldviews is a challenge as well as a potent creative force. The combination of the uniqueness of each learner and the richness of each learner's perspective argues persuasively for more emphasis on a pedagogy that emphasizes community, culture, and ethics as well as the acquisition of knowledge, content, and skills.

Finally, our campus environments—physical and online—are the places where structured teaching and learning takes place. Just as we evaluate and redesign the teaching and learning processes between faculty and students, so too must we redesign the environments in which such processes occur, ensuring that the design and tools we select support the growth of the unique brains we are responsible for nurturing.

[Note: This paper is adapted from a presentation at the League for Innovation Conference on Information Technology, November 9, 2004. Earlier versions of these ideas have been published in articles in *Campus Technology* and used in faculty development workshops.]

References

Boettcher, J. V. 2003. Design levels for distance and online learning. In *Distance learning and university effectiveness: Changing educational paradigms for online learning*, ed. R. Discenza, C. Howard, and K. Schenk, 21-54. Hershey, PA: Idea Group.

Bransford, J. D., A. L. Brown, and R. R. Cocking. 2000. *How people learn: Brain, mind, experience, and*

school. Washington, DC: National Academies Press. http://www.nap.edu/books/0309070368/html/ (accessed January 9, 2007).

Bruner, J. S. 1963. *The Process of education.* New York: Vintage Books.

Collins, A., J. S. Brown, and A. Holum. 1991. Cognitive apprenticeship: Making thinking visible. *American Educator* 12 (6): 38-47. http://www.21learn.org/arch/articles/brown_seely.html (accessed January 9, 2007).

Daniels, H. 2001. *Vygotsky and pedagogy*. New York: RoutledgeFalmer.

Damasio, A. 1999. *The feeling of what happens: Body and emotion in the making of consciousness*. New York: Harcourt.

Dewey, J. 1933. *How we think.* Reprint, Boston: Houghton-Mifflin, 1998.

Freeman, W. J. 2000. *How brains make up their mind.* New York: Columbia University Press.

Gagne, R. 1965. *The conditions of learning*. New York: Holt, Rinehart and Winston.

Knowles, M. H., F. Elwood, and R. A. Swanson. 1998. *The adult learner: The definitive classic in adult education and human resource development*. Houston: Gulf Professional Publishing.

Oldenburg, R. 1999. *The great good place: Cafes, coffee shops, bookstores, bars, hair salons, and other hangouts at the heart of a community.* 3rd edition. New York: Marlowe & Company.

Pinker, S. 1997. *How the mind works*. New York: W.W. Norton & Company.

Vygotsky, L. S. 1962. *Thought and language.* Trans. E. Hanfmann and G. Vakar. Cambridge: MIT Press.

Vygotsky, L. S. 1978. *Mind in society: The development of higher psychological processes*. Trans. M. Cole. Cambridge, MA: Harvard University Press.

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