The Implications of Brain Research for Distance Education

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Abstract

This article presents information drawn from research on brain processes that impact perception, memory, learning, and understandings about the world. This information is related to the use of interactive video and the Web in distance education through a discussion of how best to enhance learning - or mitigate problems caused - through the use of these technologies.

Introduction

Several excellent books on the latest brain research have been published recently and they are highly readable for a lay person (something the original research studies with their scientific terminology are not). These authors offer some insight into why humans have such idiosyncratic views, unique perceptions, and frail memories.

It has been especially instructive to read these with an eye to examining the results and their possible impact on the use of technology in distance education. What is fascinating in this large body of research is an emerging view of the brain as a complex system for creating coherence and consistency, even as it allows for the detection of novelty and the revision of knowledge to form new views of the world. And while much of what follows may apply to education as a whole, some insights into brain operations have special implications for the use of technology.

Ultimately, attention to these insights may improve student learning and answer the question concerning the appropriate role of technology in distance education or in campus-based courses. Perhaps the latest brain research can help us better understand the advantages and disadvantages of these technologies for adult learners, how students' brains are wired and how that wiring interferes or supports the use of interactive video or the web, and how best to mitigate any obvious disadvantages. Many of these insights are woven throughout the review of brain research, beginning with the limbic brain, model development, learning and memory, language and media, and concluding with some thoughts on how to apply these research results to inform distance education design, practice, and management.

Making Connections with the Limbic Brain

The brain is actually three brains: the ancient reptilian brain, the limbic brain, and the cortical brain. This article will focus on the limbic brain, because it may be most important to successfully using interactive video or web-based video. The limbic brain monitors the external world and the internal body, taking in information through the senses as well as body temperature and blood pressure, among others. It is the limbic brain that generates and interprets facial expressions and handles emotions, while the cortical brain handles symbolic activities such as language as well as action and strategizing. The two interact when an emotion is sent from the limbic to the cortical brain and generates a conscious thought; in response to a feeling of fear (limbic), you ask, "what should I do?" (cortical).

But it is the reliance on the face as the means of communication between mother and child that creates the "limbic response," the "symphony of mutual exchange and internal adaptation whereby two mammals become attuned to each other's inner states" (Lewis et al., 2000, p. 63). A baby, viewing a videotape of the mother's face, becomes distraught; the baby needs the mother's synchrony - to see her face in real time - to restore its mood. For example, eye contact is not just important for conveying messages, it is the means by which two limbic systems come into contact and affect each other. This would seem to imply that any technology that did not allow eye contact would also impact the level of limbic connection - the exchange of emotions and understandings - between humans. However, adults have other tools to share emotions such as language and body movement (e.g., conversations and gestures), but perhaps this limbic connection is a requirement that technology cannot fully overcome. This argues for not relying solely on technology in the more formative years or augmenting video sessions with face-to-face sessions where eyes can make contact in real time.

The importance of direct eye contact and deciphering body language is also important for sending and picking up clues about social context. "Conference calls can be so awkward [because] they remove many of the cues used for effective negotiation" (Brown & Duguid, 2000, p. 49) such as making eye contact or nodding to indicate who will speak next or signaling interest to speak by raising a hand. These cues can be lost in some interactive video settings due to poor camera location or a camera that has missed the speaker's facial expressions or is directed to another site. Interactive video may require students to guess when an appropriate lull has arrived, to interject themselves (sometimes forcefully), announce their intention to speak, and wait for recognition by the faculty person. Students wishing to respond face the same challenge, creating a stilted interaction that has none of the speed, spontaneity, and communal give-and-take of discussions without technology. The loss of social cues is important because it may affect the quality of the content of the presentation (by not allowing timely feedback or questions) but also because students may feel less engaged and become frustrated with the interaction, and subsequently lower their assessment of the class and the instructor (Reeves & Nass, 1996). Fortunately, faculty can provide such social cues verbally, once they are aware of the importance of helping students use these new media.

Attachment theory also supports the importance of physical and emotional connections. A lack of human interaction - the handling, cooing, stroking, baby talk, and play - is fatal to infants. Human contact ranks with food and water as a physiologic need (Lewis et al., 2000, p. 70). And while adults in higher education can be presumed to have their physiologic and attachment needs met earlier in life and through other current relationships, the lack of an opportunity to interact by touch or conversation may mean that the human connections that make a class cohere (and individuals become involved in class) are lost. This lack of direct connection may also affect the sharing of mental states, and "sharing states may be a crucial part of the bonding or attachment process" (Putnam & Shanor, 1999, p. 69), which may be as important for the bonding of mother and child as it is for modern classrooms filled with mature adults or a class attempting to create a community of learners.

The importance of human connections is especially pertinent when a group member suffers a significant loss (such as the death of a parent, a child's serious illness, a sudden car accident), and as with any group of adults, loss is a reality of life. The loss of a parent, job, or relationship tends to intrude in a person's daily life as they grapple with making sense of the changes happening to them, coping with change, and discovering new behaviors to be successful in a changed world. Such loss has an impact on the individual's cardiovascular function and immune processes and is heightened by isolation. Certainly, the social support of being in a class surrounded by fellow students ought to be of some assistance, if the technology supports the limbic connection (one that depends on touch, eye contact, and an emotional exchange) or the faculty can verbally provide an opportunity to recognize these emotional events.

Connecting Through Emotions

Understanding the process whereby limbic connections are made may also explain such highly charged thought processes or emotions such as racism, labeling, or any nonrational response to new individuals or situations. "A single unpleasant episode with one member of a visual category sets up a limbic connection that is inappropriately generalized to include all members of that class and is notoriously impervious to 'intellectual correction'" (Ramachandran & Blakeslee, 1998, p. 171). This occurs because the amygdala assigns emotional significance to incoming information . . . it can, and does, operate outside consciousness . . . emotional tagging, which occurs in consultation with our memories, allows us to instantly judge and then react to the world . . . strong emotions can . . . cause us to prejudge the environment (Ratey, 2001, p. 121).

The limbic brain also explains the importance of emotions on judgment as well as the predominance of emotions. There are "many more connections from the small emotional limbic center into the large logical and rational cortical centers than the reverse, which may be the reason that emotions are more dominant in determining behavior and why we sometimes react or speak before we think" (Ratey, 2001, p. 228). This may explain why emotions sometimes dominate more rational processes, especially in class discussions on sensitive subjects, on-line flaming, or in relationships among students and faculty.

Because the limbic system is based on physiologic and emotional messages that take time to relay and return, relationships among people "live on time." Relatedness "is a physiologic process that . . . admits no plausible acceleration" (Lewis et al., 2000, p. 205). This argues for a recognition that relationships built over distances and made possible by technology take time to develop and attention to maintain, be they the relationships built among students or between faculty and students. As Lewis et al. (2000) put it, "Advances in communications technology foster a false fantasy of togetherness by transmitting the impression of contact - phone calls, faxes, email - without its substance" (p. 205). Or in other words, real contact is limbic contact: the physical, emotional, and eye-to-eye connection between individuals. This would seem to argue for some face-to-face communications, not mediated by video screens, and the recognition that class relationships take time to form, perhaps indicating a need for class sessions that extend beyond the standard 10- or 15-week term, or a set number of hours in a week, or 50 minutes spent together every Monday morning.

Building - and Revising -- Models

One of the more amazing feats of the brain is its ability to take numerous inputs (from thoughts and emotions arising within the body and sensory inputs from the outside world) and construct a sensible view of what is going on in the world.

At any given moment in our waking lives, our brains are flooded with a bewildering array of sensory inputs, all of which must be incorporated into a coherent perspective that's based on what stored memories already tell us is true about ourselves and the world . . . the brain . . . [sifts] through this superabundance of detail and [orders] it into a stable and internally consistent 'belief system' - a story that makes sense of the available evidence. Each time a new item of information comes in we fold it seamlessly into our preexisting worldview (Ramachandran & Blakeslee, 1998, p. 134).

The brain fits new information into existing categories or understandings based on prior memories and learning, keeping the person's worldview relatively coherent over time. This means that the brain helps "create your own 'reality' from mere fragments of information, that what you 'see' is a reliable-but not always accurate-representation of what exists in the world, that you are completely unaware of the vast majority of events going on in your brain" (Ramachandran & Blakeslee, 1998, p. 228). This may explain the individual's ability to deceive him or herself and to create and live in another reality, a reality that others have difficulty accessing or understanding. Although it is not clear how the web could be used to offset this tendency (nor whether it is a problem in all cases), it is likely that web-based exercises could be created that would help an individual become more aware of these processes and the role self-deception may serve in one's life. The extent to which our current knowledge is the result of prior beliefs or understandings cannot be underestimated.

The brain's neural networks respond in a pattern that is established by past experience: the more often a specific pattern is fired in response to a stimulus, the more firm the nerve assembly becomes . . . Input shapes the way we experience the next input . . . Experience colors perception (Ratey, 2001, p. 55).
This means that a consistency in view may be hardwired and difficult (but not impossible) to overcome. It is essential, however, to understand how much our brains automatically maintain our worlds in a fashion that is comfortable and familiar to us.

As many a struggling teacher knows, students are often impervious to learning new concepts. They may replay the new information for a test, but after time passes, they revert to the earlier (and likely wrong) information. This is referred to as the "power of mental models." As explained in Marchese (2000), when we view a tree, it is not as if we see the tree in our head, as in photography. What actually happens is that the brain's image of tree is 80% derived from information, ideas, and feelings that are already in the brain, and 20% from outside, or from new information. This would argue for using technology to create opportunities whereby the 20% of new information could be repeated in novel ways, helping to modify the existing mental model to more nearly reflect or incorporate new information. Or technology might be used to offer multiple, active learning projects, where new information may have power to revise earlier models. Finding multiple ways to change earlier learning may be a task well-suited to web-based education.

Changing our models is possible. At first, our brains "ignore the anomaly completely or distort it to squeeze it into your preexisting framework, to preserve stability" (Ramachandran & Blakeslee, 1998, p. 134), much like Freudian defenses would act to preserve one's sanity. However, the flood of new inputs that cannot fit into the old categories must be dealt with, and dealt in ways that are different for the two hemispheres of the brain.

The coping strategies of the two hemispheres are fundamentally different. The left hemisphere's job is to create a belief system or model and to fold new experiences into that belief system. If confronted with some new information that doesn't fit the model, it relies on Freudian defense mechanisms to deny, repress or confabulate - anything to preserve the status quo. The right hemisphere's strategy is to play "Devil's Advocate," to question the status quo and look for global inconsistencies. When the anomalous information reaches a certain threshold, the right hemisphere decides that it is time to force a complete revision of the entire model and start from scratch (Ramachandran & Blakeslee, 1998, p. 136).

While much hemispheric-based research has been repudiated as an oversimplification (Gackenbach, 1999), the above description of how new information eventually overwhelms an old world view may be the result of multiple brain functions - some of which work to preserve our models and others to alter - that help us both maintain and change as needed.

The key to changing an old or dysfunctional worldview may well be to overwhelm the brain with inconsistencies, in the hopes the right hemisphere takes on the task of forcing a revision of earlier learning. This is another argument for web-based exercises that introduce multiple inconsistencies to the student's existing concepts in ways that encourage self-doubt to arise and forces a self-examination that sends the learner on a search for a better interpretation of the information.

Learning - and Changing Learning -- in the Brain

Learning is a function of how the brain forms connections between synapses, which is largely a chemical process, where routes through synapses are laid down and then repeated to form stronger and stronger connections.

Every new experience causes the neuronal firing across some synapses to strengthen and others to weaken . . . the pattern soon disappears unless it is made more permanent by LTP, which is the cellular mechanism that causes synapses to strengthen their connection to one another, coding an event, stimulus, or idea as a series of connections . . . LTP blazes a new trail along a series of neurons, making it easier for subsequent messages to fire along the same path (Ratey, 2001, p. 191).

Learning, then, occurs through a process of either strengthening or weakening synaptic connections. This process eventually results in connections that respond automatically or that finish the sequence once the initial legs of a series of connections are begun (which explains why some learning is so difficult to change). However, these connections also affect future learning: "Each perception influences all subsequent perceptions and therefore what the brain is ready to perceive" (Ratey, 2001, p. 65).

Cognitive science also addresses the environment by which improved learning occurs. As rats are raised in different conditions, varied in terms of having toys (or not), regularly having new toys (or not), and having more rats (or fewer) to interact with, they learn more. A richer environment with more interaction with others improves rat intelligence by 25%. While drawing analogies between rats and humans makes both researchers and practitioners uncomfortable, perhaps it can be comfortably concluded that environments filled with novelty and others to interact with are conducive to more active brains. And while it is a stretch to move from rats to humans to distance education, this does argue for the continued importance of changing environments for students - from listening, to discussing, to doing, to reporting, to critiquing, etc. - whether in the classroom or other educational environments. It also argues for the importance of interacting with others, perhaps for the limbic connections or the stimulation it provides. In any case, these findings argue for a varied and rich experience in an interactive video classroom, one that does not devolve to faculty lecturing and modest question-and-answer periods over the entire term of the class. They also argue for using a variety of group activities where the members of a group may change from activity to activity, as the groups engage in mini-discussions to threaded or focused conversations to projects to reports, all of which can be accomplished over the web using standard courseware packages (e.g., WebCT, Blackboard). All of these activities should be initiated by instructors, class members, outsiders, or current events in order to increase the potential for stimulation and multiple interactions.

Learning, however, is not permanent and can be changed, through an application of will and practice. "A person who forcibly changes his behavior can break the deadlock by requiring neurons to change connections to enact the new behavior. Changing the brain's firing patterns through repeated thought and action is also what is responsible for the initiation of self-choice, freedom, will, and discipline" (Ratey, 2001, p. 36). This is good news for the willing learner, and appropriately designed web-based situations may be able to help learners force new connections by practicing new behaviors or new knowledge. For example, this could encompass learning new approaches to mediation by practicing new responses in a simulation exercise tailored to offer a student ways to practice new behaviors in a safe environment.

Pursuing Novelty Through Attention

However, if one thinks that brains are wired to keep us tied to our pasts, it is essential to understand the force of attention, which balances our predilection for stasis with a preference for novelty. Attention is selective, finding and focusing primarily on novelty, and ignoring the usual. "Attentional specificity . . . [is a] mechanism for shutting down inputs when they are repetitive, unnecessary, or should be ignored" (Ratey, 2001, p. 108). It pays attention only to specific images in its visual field - for example, focusing on the picture and not the wall on which it hangs -- and ignores everything except for the novelty it craves. This is good news for the educational designer, who can use the brain's attentional specificity and its search for novelty to draw students into material with visual cues or new concepts. That is, until the once-novel design elements becomes the everyday and ordinary. This may explain why attention-getting devices often lose their power and material must be regularly redesigned to challenge students' expectations and need for novelty.

Storing and Retrieving Memories

Capacity for memory is neither infinite nor permanent. Short-term or working memory holds small amounts of information for only a few seconds at a time, it is the "brain's RAM, or rapid access memory . . . a space where many things can be held together and manipulated, so we can process them, evaluate them, rehearse them, make decisions about them" (Ratey, 2001, p. 131). Long-term memories are stored by the hippocampus which is "like an intelligent collating machine [that] filters new associations, decides what is important and what to ignore or compress, sorts the results, and then sends various packets of information to other parts of the brain" (Ratey. 2001, p. 188). Long-term memory can be fairly permanent, although certain problems can and do occur.

First, a problem can arise due to poor sorting or storage decisions by the hippocampus.

Second, memory retrieval - reconstructing the memory from places around the brain -- may be inaccurate. Bits and pieces of a single memory are stored in different networks of neurons all around the brain. We bring the pieces together when it is time to recall that memory . . . formation and recall of each memory are influenced by mood, surroundings, and gestalt at the time the memory is formed or retrieved. That's why the same event can be remembered differently by different people (Ratey. 2001. p. 186).

The third problem can occur when memories fade or are changed by new events. "Memory also changes as we change over time. New experiences change our attitudes, and thus how and what we remember . . . daily experiences constantly alter these connections, a memory is a bit different each time we remember it" (Ratey, 2001, p. 186). For example, negative events impede memory of earlier material, which is called retroactive interference (Reeves & Nass, 1996, p. 121). Memories affect potential future learning and can be changed retroactively by later learning.

The problem with memory storage and retrieval is crucial to understanding why students do not remember material presented to them in earlier courses, or they remember the material imperfectly or incorrectly. Web-based modules may help refresh learning from earlier units or courses and be available prior to a course to help students remember earlier material. The role of memories to affect future and prior learning is also an interesting conundrum for educators. Whether a lesson may change earlier learning or impact future learning for ill or well is beyond the skills and insight of most educators (for it would presume some special knowledge of a student's memories). This may indicate a need for web-based modules that capture earlier and current lessons, so that students may either maintain or change their learning to more nearly approximate their intentions.

Before leaving this discussion of memory, there is an intriguing insight into memory from Pribram (1999). Memory is organized both as a surface "program" and as a deep, distributed code, and each system combines to create a "suprasystem" (Pribram & Meade, 1999, p. 209). These systems form a web, which is perhaps only an interesting semantic coincidence, or a clue as to why the Internet is fascinating to many. The new theories of the brain as "three-dimensional and holistic" and distributed throughout the entire body, including fingers and toes (Shanor, 1999, p. 15) may also provide an interesting clue to why the web, which humans interact with through visual and physical (through the keyboard) means, is so intriguing with its resource of interconnected and multi-layered information.

Thinking Before Acting Through Language

Language has a variety of functions, from providing for self-reflection between stimulus and action to enabling thought to be spoken and persons to achieve a modest level of mutual understanding and simple communication. As "a delay mechanism [language] improves and refines our thoughts, allowing us to remove ourselves from the present, to symbolically hold objects in our minds and manipulate them into different potential sequences before taking action" (Ratey, 2001, p. 253). Self-talk is the "the root of empathy, understanding, cooperation, and rules that allow us to be successful social beings. Any sense of moral behavior requires thought before action" (Ratey, 2001, p. 255).

The web may be an appropriate vehicle for thinking and rehearsing thought through the use of language to communicate via e-mail, threaded discussions, or chat rooms. Early evidence does indicate that use of simple e-mail to communicate forces students to improve written communication, writing longer and more grammatically complicated sentences, and to respond in a more thoughtful fashion by taking the time to reread postings, edit drafted messages, and ponder responses.

The role of language in the creation and maintenance of social skills and interpersonal relations is also vitally important. Language has long had a purported role on the development of social skills in infants. However, what about adults whose social skills may be less than ideal? "Individuals with faulty social brains can improve their behavior by seeing something done properly, hearing it, walking through it, and acting it out in various situations" (Ratey, 2001, p. 299). Social skills can be practiced over interactive video, which - because of the need to be deliberate and careful with interactions -- creates a slow, stilted communication style, but one that may be appropriate for the purpose of identifying a better response in a social situation, discussing why it may be a better response, and practicing the new interaction.

Creating a "New Brain" Through Media?

Healy (1999) argues that based on what we know about brain development in children, new computer media may be responsible for developing brains that are largely different from the brains of adults. This is because "many brain connections have become specialized for . . . media" (p. 133); in this view, a brain formed by language and reading is different from a brain formed by hypermedia. Different media lead to different synaptic connections being laid down and reinforced, creating different brains in youngsters raised on fast-paced, visually-stimulating computer applications and video games. "Newer technologies emphasize rapid processing of visual symbols . . . and deemphasize traditional verbal learning . . . and the linear, analytic thought process . . . [making it] more difficult to deal with abstract verbal reasoning" (Healy, 1999, p. 142).

The implications for higher education of this view are two-fold. First, it is likely that students arriving in higher education will have different brains (formed by years at video games, computer simulations, and web researches) than their teachers (whose brains were formed by early experiences with text). This disjunction is likely to cause communication problems and different perceptions of what is a well-designed (or useful, relevant, or cool) learning experience. Furthermore, as new media come on the scene and are adopted by schools and families, they will continue to "affect the underlying neural circuitry that is being established during childhood and adolescence" (Healy, 1999, p. 131). That means further changes in the brain structures and capabilities of each group of students are likely, thereby creating ever more differences to the brain capabilities and understandings of older or more traditionally educated faculty.

If Healy is correct, then higher education may need to use media and web-based materials to capitalize upon the next generation's brain connections. However, more traditional instructional methods should also be used to ensure that students are able to reason in traditional linear and logical fashion. Given the web's ability to present long sections of text and retain some of the characteristics of linear discourse, it may be a tool that is sufficiently flexible as to support both aims.

Keeping Older Brains Healthy

There is good news for adult learners, too, from the brain research available today. Just as the new media may be forming a different brain - with different capacities - in youth, older brains may change as well. Even after injury, "new, highly precise and functionally effective pathways can emerge in the adult brain" (Ramachandran & Blakeslee, 1998, p. 31) in as early as four weeks. This is due to the brain's amazing plasticity, the ability of "undamaged neurons [to] take over, changing the number, variety, and strength of the messages they send, rerouting traffic around the accident site. Rewriting is possible throughout life" (Ratey, 2001, p. 38).

And to keep brains healthy, research shows the importance of "physical and mental exercise, proper nutrition, and adequate sleep will help anyone gain cognitive clarity and emotional stability [as well as] spirituality, meditation, even the pursuit of one's passions" (Ratey, 2001, p. 356). But one of the best avenues to encourage healthy brains is to pursue learning, as learning "'exercises' the brain, giving it the stimulants it craves. A well-toned brain often has more blood capillaries and glial cells . . . if neurons . . . weaken, the memory weakens" (Ratey, 2001, p. 193).

If continued learning is key to keeping a healthy brain, then adult distance education students should be reassured. For they have already enrolled in college courses, haven't they? Distance educators must provide the important conditions of healthy brains and good learning: challenge, new content, and new persons to interact with. These are easy elements to design into courses be they via interactive video or web-based and they also support the brain research that indicates that the number and variety of interactions - with people, toys, language, books, information -- are important to brain health and stimulation.

Equating Media with Real Life

In The Media Equation, Reeves and Nass (1996) provide insight into one of the more counterintuitive and befuddling aspects of the interaction of people with different media. In other words, people treat computers as if they were people, and thus, they conclude "media equal real life" (p. 5). Their experiments find this is true despite the type of media used or the age and expertise of the user. And it is true even when the user "knows" media is a tool to serve individual needs, has no personality and no qualities that have not been programmed into it. The difference between "knowing" and acting reveals the unconscious aspect of our mistaking media for real life. That is why asking subjects to reflect on their relationship with media has lead to spurious insights. The 35 research studies described by Reeves and Nass (1996) often relied on tapping into brain functions to determine that people treat media as if they were real.

Why is this so? The human brain evolved in a world in which only humans exhibited rich social behaviors, and a world in which all perceived objects were real physical objects. Anything that seemed to be a real person or place was real (Reeves & Nass, 1996, p. 12).

Our brains continue to mistake persons, situations, and emotions depicted by media as real persons and situations, and the emotions users experience are felt physiologically as well as mentally. When presented with mediated situations, neural activity and emotional responses were the same as if the situation were real. A face presented full frame in the computer is experienced as "closer" than a face surrounded by backgrounds; the physiological impact is the same for the full face as if the person had walked up and closed an equivalent physical distance. As long as media capitalize on the social rules of human relationships - rules humans already know and use daily - the media will be accepted and treated as real.

There is both good news and bad news in such research results. The good news is that media will not markedly affect or change the personality or relationship of those who use it for educational purposes. The instructor and student will be able to communicate over media without any diminution of emotion or personality, as if the media were a window through which the two may talk without worrying that the window might change the impact of our words or alter the emotional connection. A face can have many of the same benefits as a face in real life, without requiring physical travel to bridge the actual distance between speakers. The bad news is that media can no longer be blamed for a bad class or poor communication and that instructors will need to continue to improve their instructional skills rather than blame poor results on the technology.

Given that this review began with the research on the importance of limbic connections, how are these results of Reeves and Nass (1996) to be interpreted? Can interactive video or web-based video be used to establish limbic connections, or not? The "media equation" seems to imply that users will treat the mediated situation as if it were real, respond as if it is real, even as they consciously know the difference between mediated and real experience. Even so, would an education that was entirely mediated be a good idea? Healy (1999) would certainly argue that for children, an early and/or steady diet of media might be harmful. And even for adults, good sense might support the old rule of moderation in all things, including media. But when it is used in distance education, greater emphasis should be placed on designing quality learning experiences than on worrying about the spurious effects of technology.

Using Technologies in Light of Brain Research

This review of brain research gives those who use interactive video or the web for distance education plenty to contemplate as they plan courses and programs of study. Clearly, just because there are some disadvantages to these technologies, one should not preclude their use; these technologies remain a viable means of reaching students who may have no other means of enrolling in courses. However, their use may need to be modified to offset difficulties with the technology in light of brain functions.

This review would seem to argue for a mixed model for distance courses, including bringing students together physically to meet each other and make initial limbic connections or to discuss difficult topics. One could imagine a time when such a physical meeting might not be needed (say, when a group of students has been together for some time), yet students may prefer an occasional meeting to forge or rekindle friendships, share problems, or gripe, despite the difficulties of travel and time away from family and work.

We may need to actively support emotional responses, including emotions felt about the material as well as personal experiences, and these can be elicited in on-line discussions or classes delivered over interactive video. We may need to recognize how emotions reinforce or revise learning in ways that cannot be ignored nor foreseen. We may need to go beyond the shorthand of emoticons in online messages, and use language to express emotions beyond the simple, "I'm sad" to a richer description of what we feel and why.

We may adopt language cues to replace the body or facial cues we would normally depend upon in face-to-face conversation. Faculty may need to establish rules for conversing via interactive video that are more "directive," indicating which site speaks next or which person. The faculty person acts as a traffic or crossing guard, a role needed especially when normal social cues are missing. We may need to emphasize the use of clear and expressive language whenever the recipient cannot see the speaker's body language and facial expressions. We may need to find a way to express touch and emotion when needed, say when a student's loss must be assuaged. All of these require that faculty and students develop a more self-conscious style of communicating, eschewing assumption about others, and responding to others on the basis of stated cues rather than appearances.

We may need to recognize the human need for time to establish relationships, to bond with classmates or the material. This may mean that courses are offered in multi-term formats (e.g., Fall and Spring), or in larger blocks of time in the day or week. This may be easily augmented by use of threaded discussions or other online formats such as chat sessions to help students and faculty form these important bonds.

We may need to design web-based courses that offer opportunities for useful repetition of learning, although the brain will ignore too much repetition. The line between the two may be both fine and moving, and in any case, it may be a "line" for one individual only. Perhaps one solution will be to design web-based situations where students can rehearse learning in a variety of contexts, avoiding too much rote repetition and yet strengthening the synaptic connections that support the new learning. Doing this would also likely enhance the transfer of learning from one situation to a different one, a problem that has plagued educators for many years.

We may need to design a variety of learning experiences that help students change a prior worldview or inaccurate learning and provide several opportunities to receive new and different views in an effort to encourage the brain to revise its model and change its current synaptic connections. The web may be a good choice for presenting a variety of these types of world-altering experiences, although whether it is ultimately effective in this role should be investigated.

Given the force of prior learning on current beliefs and understandings, we may need to modify learning experiences so that students can map out different paths through the curriculum that help modify or reinforce the earlier learning and, in the latter case, build upon it. We will want to design a variety of experiences to capitalize on the brain's need for variety and a rich environment, including different types of tasks, different groupings of students, and different settings for learning. We may need to use novelty more frequently and to better purpose, capitalizing on the brain's preference to attend to novelty and the rapid devolution of novelty into the everyday and the boringly repetitious.

We may need to recognize that the traditional problem of a student not learning material presumed taught in an earlier class (or grade) may be caused by poor learning or poor memory, inadequate retrieval of the memory, or later interference with earlier learning. Rather than punishing the student, we may need to develop web-based modules to help students "refresh" or relearn the material, and rehearse it to better lay down the appropriate connections in the brain.

We will need to watch for the "new brains" of our younger students. This will require that we design for their new abilities and provide ample opportunities to augment lesser-used skills. We will need to be aware of our own different brains as faculty and not presume that student brains work the same as ours, and that these changes will likely continue to happen as new technologies mold different brain capacities in another generation.

We may need to provide the stimulation and new experiences to help older brains continue to learn, using our technologies to enable interactions with other students and faculty as well as with interesting and challenging new material. Lifelong learning is not just a slogan, but a necessity for our brains. We may need to encourage students to exercise their bodies along with their brains and understand the connection between them. This may require less time at the computer and more time taking breaks to rest or refocus eyes, stretch limbs, and move about. We may need to shape web-based environments that capitalize on the human need for following the same social rules as in real life, including politeness and use of praise. The mediated environment can be experienced much like face-to-face interaction, so many of the same rules will need to be applied. Designing web environments can capitalize on these rules.

Interactive video and the web may not be perfect tools, but we can design and manage programs that use them to support the educational process and improve the quality of student learning. While these tools could inadvertently expand or solidify the distances between us, avoid limbic connections, and be used in ways that are repetitious, it need not be this way. What we know about brain processes supports the use of technology to modify the brain's tendency to maintain coherence at the cost of new concepts, to keep a consistent worldview despite clues to the contrary, and to have new learning and memories be heavily influenced by earlier learning, keeping us tied to the past. Technology, and especially the web, has a flexible format that creative designers can use to make learning memorable and new ideas acceptable. While it may not solve every problem, technology is certainly a most useful tool is used wisely by those committed to quality distance education.

Biographical Note

Dr. Meyer is currently assistant professor of educational leadership at the University of North Dakota, focusing on higher education administration and policy. She recently served as Director

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