

The Future is in the Margins

The Role of Technology and Disability in Educational Reform

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Table of Contents

Introduction 1

Impediments to change 1

First precipitant to change: The needs of students “in the margins” 3

Second precipitant to change: The capacities of computers and digital media 4

Conclusion: Students in the Margins, Technology, and Educational Reform 14

References. 16

Introduction

New technologies are often heralded with great fanfare and elaborate claims of their transformative power. Educational technologies, notably the personal computer, are a case in point. Scattered examples can be found across education of productive uses of new technologies: the use of the World Wide Web to connect students from around the globe in international learning communities; online learning projects that give rural, homeschooled, or night school students access to courses at distant schools or at odd hours; use of handheld computers for data collection on field trips. Yet some 25 years after the first computers found their way into schools, their anticipated role in expanding opportunities for teachers and students alike remains largely elusive. Despite their promise, these technologies still are used largely to support old goals, methods, and assessments that shut out students with disabilities from the general education curriculum.

In this chapter we examine some reasons for the slow progress towards educational innovation and change that continues to seem just around the corner as the power of computers and networks increases exponentially. We posit that students “on the margins,” for whom current curricula are patently ineffective, can actually lead the way to true reform because they help us understand weaknesses in our educational system and curricula that impede teaching and learning for all. Through the framework of Universal Design for Learning (UDL), we articulate a new view of the nature of learner diversity and show that designing digital tools and content to respond to that diversity yields a viable blueprint for change.

Impediments to change

One reason that computers have not yet fulfilled their transformative promise in education is, paradoxically, their incredible power and versatility. When technologies with radically new capacities are introduced, it takes people a long time to realize how to use those capacities creatively and productively. Indeed, the capacities themselves often change the very enterprise for which they are designed, requiring a shift of viewpoint that can only happen when users have had time to experiment with the new tools.

The early days of film offer a good example. The first moviemakers simply transferred stage productions such as plays and stand-up entertainment onto film by setting the camera in one place in front of a stage. It took nearly 20 years for filmmakers—notably D.W. Griffith in 1913—to start experimenting with multiple camera angles, zooming, panning, and many other techniques made possible by film and video media (Stephens, 1998). The technology to do these things was in place early, but people needed time to discover the capacities of movie cameras and to shift their mind-set away from the old, more limited methodologies of the stage.

Looking back even further, Ruth Cowan (1983), in her remarkable work of social history called *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*, examines the effects of new technologies in the kitchen. When stoves were invented in the 18th century, they were embraced very slowly. Two things slowed their acceptance. On one hand, there were widespread fears about their deleterious effects on health and family life (similar, in fact, to early fears about computers in the home or classroom). On the other hand, stoves seemed to provide only a marginal improvement over the open hearth—especially since they were initially used only to cook in the same old way: mixing and heating food in a large pot hung over the fire. However, the great flexibility of stoves eventually became apparent and stoves ultimately transformed our culture’s concept of what constituted a meal, what was meant by cooking, and even what a kitchen was for. Most important, Cowan writes, the new technologies of the kitchen democratized cuisine, bringing meals that were more nutritious, more differentiated (multiple dishes, multiple courses), and more attractive to a large number of households where such meals had been previously unavailable.

Although it seems that computers have been in the classroom for a long time now, as a technology they are still relatively young. Like most technologies in the early stages of application, classroom computers are mostly being used in traditional ways—new tools to do old things. Word processors, calculators, and learning games have been assimilated into conventional curriculum to support and augment traditional instructional activities (Reinking, Labbo, et al., 2000).

These tools provide improvements in efficiency over print-based technologies (pencils and paper), but the ways in which they are predominantly being used do not fundamentally change the nature of the educational enterprise. The core components of the curriculum—its goals, media and materials, teaching methods, and assessments—remain essentially as they always have been; in particular they still rest on a print-based set of assumptions (Smagorinsky, 1995; Pailliotet, Semali, Rodenberg, Giles, & Macaul, 2000). Computers are widely used to help students become more proficient with comprehending, interpreting and analyzing, and expressing themselves with printed text.

The second reason that computers have been slow to bring about change is, again ironically, the incredible power of the technology of printed text. The advent of printed text revolutionized communication by enabling permanent recording, mass production, portability, and, at least by the 20th century, affordability. Print made possible the very idea of education for everyone, and became its cornerstone. Learning to read and write text, to interpret, organize, and apply information encoded in text have been the key to learning and to citizenship, and have therefore been at the core of the educational system. These assumptions are of such long standing that they are almost invisible, and so entrenched that to consider dislodging them seems radical and possibly dangerous. Why should we dislodge the print-centric curriculum, and what will bring it about?

First precipitant to change: The needs of students “in the margins”

The urgency for change stems in part from schools’ inability to meet the needs of increasing numbers of students “in the margins”—those for whom the mastery of printed text is difficult or impossible. A significant minority of people can be considered “print disabled,” because of visual impairments, learning and other cognitive disabilities, sensory or motor disabilities, and many other reasons. The medium of printed text can be partially or totally inaccessible, or simply not the optimal medium for learning and expression. One urgent reason for change derives from the rapidly increasing diversity of learners in our classrooms and the limited capacity of printed media to respond to that diversity.

Printed text is inaccessible for students who cannot see; those who have difficulty recognizing phonemes, letters, letter-to-sound correspondences, words, or sentences; or have trouble distinguishing different print formats and their associated reading conventions (Adams, 1990; Anderson, Hiebert, Scott, & Wilkinson, 1985). In addition, because reading is not only an act of recognition but also one of strategy (Anderson, et al., 1985; Graves & Levin, 1989; Richek, List, & Lerner, 1989), printed text can also be a challenge for students who have strategic difficulties (Rayner, 1986). Difficulty setting a reading goal, interpreting structural cues and meaning within text, making connections to background knowledge, self-monitoring, all exemplify strategic weaknesses that can make printed text a barrier. Moreover, learners who cannot readily decode the words must recruit strategic resources for the task, limiting the availability of those resources for the construction of meaning. Printed text can also inhibit those who do not have disabilities per se but could be considered to have print disabilities. For example, English language learners in the United States often lack the vocabulary or background knowledge they need to succeed in a learning environment dominated by printed text (Proctor, Carlo, August, & Snow, 2005).

Beyond issues of skill and access, emotional and motivational issues can inhibit progress in learning. Students whose failures with printed text have caused them to build negative associations with the medium can become discouraged and lack the confidence that further efforts will yield progress. Finding the will to persist further with an unforgiving and unsupportive medium can be daunting (Richek & McTague, 1988). And students for whom printed text is just not an optimal medium can also become disaffected in a print-centric classroom. These students may flourish when provided with other presentational and expressive options, such as multimedia or the arts. For example, filmmaker George Lucas, creator of *Star Wars* and *Indiana Jones*, admits he was not very engaged in school, in “memorizing isolated names and facts.” But his obvious gifts in the medium of film made him realize that other avenues for success are highly legitimate. These insights motivated him to establish an educational foundation to explore new ways of teaching and learning using multimedia (Lucas, 2002).

Many kinds of learners may share the same classroom; all may struggle to learn the same material. Yet the heterogeneity of their learning needs contrasts with the monolithic label of “struggling learner.” The students struggling with text may actually have little in common and be inappropriately grouped under any kind of label. The common barrier they face is a curriculum based in printed text. The fundamental quality of printed text that renders it inaccessible and unforgiving is its fixed nature. Printed materials cannot be modified from their original format (unless an enterprising teacher takes out scissors and tape!), nor can printed content be enhanced or modified to make it supportive in diverse ways for diverse learners. Until the advent of computers and digital media, there was really no workable alternative to print- and text-centric curriculum.

Disenfranchised students “in the margins” of our educational system provide the needed challenge for curriculum designers, administrators, policy makers, and teachers. They help us to see and understand the opportunities offered by computers and digital media. With the federal mandate of the Individuals with Disabilities Education Act and No Child Left Behind to provide access, participation, and progress in the general education curriculum to all students (Hitchcock, Meyer, Rose, & Jackson, 2002; Karger, 2004), schools face intense pressure to succeed with diverse learners, yet many of these learners cannot thrive in a print-based classroom. This pressure drives us to examine the qualities and capacities of new media in light of the needs of diverse learners, and to forge a path to significant change that ultimately helps all learners.

Second precipitant to change: The capacities of computers and digital media

Of profound significance for education is the unequalled flexibility of digital media. Unlike fixed printed media, digital media (if so designed) are malleable: they can be transformed, marked, linked, networked, and customized for each individual learner.

New media (digital text, digital images, digital audio, digital video, digital multimedia, hypertext, and hypermedia) are notable for their malleability. While, like print, they can provide a permanent representation, they do not have print’s fixed quality—they are more like raw clay than fired pottery. The malleability of digital media (when the materials are designed well) translates to enormous flexibility for teachers and learners: “Teaching is all about responsiveness, adaptability, and multiple strategies and resources, so the computer’s flexibility—rather than any one particular feature—is what gives it so much potential as a teaching tool” (Meyer & Rose, 1998, p.83).

Digital text separates the content from the display, which can then be flexible in several key ways. Content can be displayed in a variety of media (onscreen or printed text, speech, still images, video, animation, simulations, or combinations of these; Heimann, Nelson, et al. 1995; Mayer, 2003). Transformations can occur both within and between

these media (e.g., text-to-speech, speech-to-text, text-to-American Sign Language (ASL), text-to-Braille; Elbro, Rasmussen, et al. 1996; Hasselbring & Williams-Glaser, 2000; Loeterman, Paul, et al. 2002). Within a medium, the presentation of content can be altered in a variety of ways to suit the individual (changes can be made to type face, font size, font color, sound volume, presentation rate, conversational versus formal style, and difficulty of information; images can be turned on or off; main ideas can be highlighted (Elkind, et al. 1993; Hay, 1997; Edyburn, 2003; Mayer, 2003). The networked nature of digital media adds further flexibility, enabling the insertion of hyperlinks to learning supports such as multimedia explanations, maps, and encyclopedias; email, which provides an opportunity to consult with peers and experts; and even weblogs.

The provision of such customized, multimedia content—or even just digital text as an entry point—can reduce barriers to learning for many students. Beyond reducing barriers, it can also improve learning by allowing for multiple representations of meaning that may be used redundantly for clarity, complementarily for enhanced meaning, or even discordantly for multiple meanings (e.g., multiple soundtracks carrying dramatic content as well as directors’ narrations that offer alternate links to background knowledge or points of view).

Digital media’s tremendous flexibility enables teachers to differentiate their approaches in a way that is simply not feasible when restricted to traditional media such as print, speech, and images. With traditional media teachers would have to create or assemble a huge assortment of materials. With digital media one piece of curriculum can be designed with built-in customization features so that it can be adapted to suit many different students (MacArthur & Haynes, 1995; Hay, 1997; Erdner, et al. 1998; Edyburn, 2003). The capacity to use multiple media leads to a more diversified, flexible palette for communication—a palette that takes advantage of the varied strengths and weaknesses of each medium and enables teachers to select the medium best suited to a particular student and learning task.

The Change: Universal Design for Learning

The needs of diverse learners who have until now been disenfranchised in a print-centric world can drive us to discover, develop, and apply the astonishing power of new media to expand educational opportunities. Learning is supported and facilitated by the interaction between the learner and the curriculum. When that support and facilitation is missing, “learning disabilities” arise. If the curriculum can be flexibly designed, it can meet more learners where they need to be met. It can challenge and support the vast variety of needs, skills, and interests arrayed in a diverse classroom. Using new tools to support traditional, print-based curriculum has taught us some important things. But like other early-stage uses of new technologies, this approach has not really taken advantage of the true power of digital tools and media, nor has it provoked fundamental and significant change in education. With the early stages of educational technology

adoption behind us, we are ready to take full advantage of the power and flexibility that digital tools and content offer, and to envision new ways for teachers to teach and learners to learn.

How can we make sense of these complex changes, and move forward responsibly and quickly? At CAST we have been researching and developing a framework to guide such an effort: Universal Design for Learning. UDL is based on our two decades of research into the nature of learner differences, the capacities of new media, the most effective teaching practices, and assessments that, while based on high standards, are fair and accurate measures of student learning (Meyer & Rose, 1998; Rose & Meyer, 2000, 2002). It provides a research-based framework for applying insights about students “in the margins” to the design of curriculum. UDL’s basic premise is that barriers to learning occur in the interaction with the curriculum—they are not inherent solely in the capacities of the learner. Thus, when education fails, the curriculum, not the learner, should take responsibility for adaptation. With the UDL framework, curriculum designers anticipate and reduce or eliminate barriers by making curricula flexible.

UDL is an educational extension of the universal design movement in architecture. Originally formulated by Ron Mace at North Carolina State University, universal design’s objective is to build innately accessible structures by addressing the mobility and communication needs of individuals with disabilities at the design stage, a practice that has spread to areas such as civic engineering and commercial product design. Designs that increase accessibility for individuals with disabilities—those who are typically “in the margins”—tend to yield benefits that make everyone’s experience better.

A good example from product development is television captioning. When captioning first became available, it was intended for people with hearing impairments, who had to retrofit their televisions by purchasing expensive decoder boxes to access the captions. Later, decoder chips were built into every television, making captioning standard and available to all viewers. This universal design feature now benefits not only those with hearing impairments, but also exercisers in health clubs, travelers in airports, individuals working on their language skills, and couples who go to sleep at different times. Further, as a built-in feature, access to television captioning costs a few cents rather than several hundred dollars.

The development of UDL was also driven by the needs of individuals in the margins, for whom regular curriculum often does not work, and by an appreciation for the flexibility of new digital tools. Early experiences with flexible technologies revealed that addressing the needs of special populations improved opportunities for everyone. With the help of UDL, next-stage educational technologies will go beyond providing better access to existing methods and materials; they will embody fundamentally different concepts of learning and thus teaching (Dalton, Pisha, Coyne, Eagleton, & Deysner, 2001; Pisha & Coyne, 2001; Rose & Meyer, 2002). Applying the increasing power of

emerging technologies—including tools used in modern brain research, and guided by the needs and talents of diverse learners—UDL can help us move past the early-stage, old-use applications of new learning technologies, and change the outdated, print-centric assumptions underlying current educational practice.

What assumptions need to be re-evaluated to reap the true benefits of digital technology and really reform education? First and foremost, our understanding of learner differences. A new understanding of these differences emerges from advances in digital technologies that are parallel to those in instruction, specifically the improvements in brain research fueled by digital imaging technologies.

UDL and Learning: A New View of Learner Differences

Computer-driven technologies such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and quantitative electroencephalography (Qeeg) are revolutionizing the study of learning as it happens in the brain. These new tools and methodologies allow us to “see” the brain as it learns by performing enormously complicated computations on subtle changes in brain activity that are then displayed on a computer screen. Insights gleaned from these new techniques do not support traditional views of learners’ abilities that are based on global measures such as IQ or that segregate people into simple categories such as “the learning disabled.”

Brain research and more recent theories of intelligence such as those of Howard Gardner (1983, 1999) are showing that learning ability is far more diversified than was previously described. There are many different elements to learning, each one subject to individual differences. As a consequence, we can expect that students can be intelligent, or less so, in a nearly endless number of ways. Indeed, teachers today are beginning to discover a far more elaborate spectrum of learning ability in their classrooms.

Through new brain imaging techniques, we can actually see activity in three elaborate sets of nerve networks that play a primary role in learning. We refer to them as recognition, strategic, and affective networks to reflect their individual specializations. Briefly, the recognition networks are specialized to receive and analyze information (the “what” of learning); the strategic networks are specialized to plan and execute actions (the “how” of learning); and the affective networks are specialized to evaluate and set priorities (the “why” of learning). Collectively, these networks coordinate how we work and learn (Dolan & Hall, 2001; Rose & Meyer, 2000, 2002).

The dominant impression from computed brain images is how modular learning seems to be. To take recognition as an example, there is not one recognition center in the brain but many different areas managing different aspects of recognition. Brain imaging techniques reveal that we learn about the motion, shape, orientation, and color of an object using different parts of our recognition networks (Tootell, Reppas,

Kwong, Malach, Bor, Brady, Rosen, & Belliveau, 1995; Wallis & Bulthoff, 1999). Similarly, our brains process the word “cat” in different regions when the word is presented in print versus speech, and we use an entirely different brain area to compose the word “cat” for speaking (Kent, 1998; Petersen, Fox, Posner, Mintun, & Raichle, 1988). Brain imaging studies also reveal that reading is the result of interplay between multiple brain areas managing different types of processing (Nichelli, Grafman, Pietrini, Clark, Lee, & Miletich, 1995). For example, one area is required to discriminate fonts, another to process grammar, another to interpret meaning, and another to identify the story’s moral.

Different aspects of learning are distributed across numerous brain regions—each module highly specialized for learning about specific aspects of the world. Each of the three learning networks has a large number of such distributed modules that work in parallel, simultaneously, to coordinate the complex task of learning. Thus, even the simplest task activates multiple modules in our learning networks. The pattern of activity across different modules depends on the task—a different set of modules is active when one listens to a speech versus a symphony, for example. In a general sense, there is a signature of brain activity that corresponds to the task being performed. The distribution of activity varies not only across task but also across individuals (Xiong, Rao, Jerabek, Zamarripa, Woldorff, Lancaster, & Fox, 2000). The relative size of modules and their placement can differ from person to person, and for a given task each brain exhibits a unique map of activity, distinguishable from others by the precise set of modules involved and/or the extent of their activity (Schlaug, Jancke, Huang & Steinmetz, 1995).

Another interesting—and significant—insight gleaned from brain imaging is that the map of activity changes as a person learns. Recent research has shown that novices and experts use very different sets of modules to perform the same task. For example, when professional piano players and non-musicians perform the same finger tapping task, the distribution of activity in their brains is quite different (Hund-Georgiadis & von Cramon, 1999). Both the intensity of brain activation and the set of modules engaged may vary according to the degree of experience with a learning task (Shaywitz, 2003).

New brain imaging technologies allow us to actually watch the brain as learners develop expertise and see it shift from using one set of modules to another. The new technologies have also shown that the size of an individual processing module can grow (and others can shrink) with experience, even in adults (Raichle, Fiez, Videen, MacLeod, Pardo, Fox, & Petersen, 1994; Karni, Meyer, Jezzard, Adams, 1995; Merzenich & Jenkins, 1995; Turner & Ungerleider, 1995; Petersen, van Mier, Fiez, & Raichle, 1998). For example, the brain is able to generalize, expending less effort to process the demands of a task similar to one it has dealt with many times before. Because the brain is highly impressionable and plastic, repetition and practice produce changes not only at the behavioral level, in the form of improved performance, but also at the neural level.

This new brain research is yielding an increasingly clear articulation of the concept of learning—revealing not one, two, or three generalized learning capacities, but many different modules and distributed processes for learning within the same brain, all of which may differ from person to person and as a function of experience. Furthermore, it is becoming clear that individual brains differ from each other not in a general ability (like IQ) but in many different kinds of specific abilities. One consequence of this fact is that students that we think of as disabled because of the deficits that we see in one area may in fact have exquisite strengths in other areas. In the same context, myriad differences emerge between learners formerly classified in the category of “normal”—differences in ability to recognize patterns, concepts, and information; differences in strategic and processing abilities; and variations in engagement and motivation (Vygotsky, 1962).

The categories we have used for so long belie a far more elaborate spectrum of learning ability than is typically assumed in the classroom. Continuing the pioneering work of Gardner and others, research continues to show that there is not one typical learner with a limited number of variants but instead a great variety of learners—as many as the interactions among modules in our brains (Gardner, 1983, 1997; Gevins & Smith, 2000; Habib, McIntosh, & Tulving, 2000; Rypma & D’Esposito, 1999).

Against this backdrop, individuals with disabilities fall along a spectrum of difference, and the convention of the regular student disappears as a normative model:

One of the clearest and most important revelations stemming from brain research is that there are no “regular” students. The notion of broad categories of learners—smart, not smart; disabled, not disabled; regular, not regular—is a gross oversimplification that does not reflect reality. By categorizing students in this way, we miss many subtle and important qualities and focus instead on a single characteristic (Rose & Meyer, 2002, p.38).

In addition, the more differentiated use of media for instruction reveals that individuals who are defined as learning disabled within print-based learning environments are not the same individuals who are defined as learning disabled within video- or audio-based learning environments. Such revelations splinter the old categorical divisions between disability and ability and create new descriptors that explicitly recognize the *interaction between student and environment* in the definition of strengths and weaknesses.

Given these revelations, educators now take more notice of the strengths of individuals with disabilities—e.g., the prodigious feats of visual memory in a child with autism, the strong visual/artistic or visual/expressive skills in a student with dyslexia, or the extraordinary capacity to recognize facial expression in an individual with aphasia. Thanks in part to new technologies, we can appreciate more fully every student’s uniqueness and the importance of considering each one’s strengths and needs.

UDL and Teaching: Designing Curriculum to Reach Diverse Learners

Changing concepts of learning and individual differences compel more flexible and diversified teaching so that all learners can be appropriately challenged, supported, and engaged. UDL turns the knowledge that has been gained from brain research into a guide for differentiating instruction to accommodate many different modes of learning. The UDL framework is structured around the three sets of learning networks. Each of its three guiding principles calls for a kind of flexibility that will support individual differences relating to one of these sets of networks: differences in how students recognize essential cues and patterns, master skillful strategies for action, and engage with learning. UDL helps teachers meet every student's needs and preferences by guiding flexibility in the way teachers present information, offer opportunities for skill building and expression, and engage students (Rose & Meyer, 2002).

In support of diversity in *recognition networks*, a UDL curriculum provides *multiple means of representation*. UDL materials reflect the knowledge that there is little value in a single canonical representation of the information in any particular task or problem. Instead, we should assume that to provide basic access for students with sensory disabilities or other challenges and multiple routes to meaning for all students (e.g., representing a math concept both in text and graphically), it is necessary and preferable to provide multiple, redundant, and varied representations of concepts and information.

To support diversity in *strategic networks*, a UDL curriculum provides *multiple means of expression*, giving students flexible models of skilled performance to learn from, opportunities to practice skills and strategies in a supported environment, relevant and ongoing feedback, and flexible opportunities for demonstrating skill using a variety of media and styles. While many students may write (or type or dictate) essays, other alternatives may include rich mixes of writing, illustrating, speaking, animating, and video-making. With UDL, the method of evaluation suits the task and the means. Students are required to meet a higher standard of expressive literacy—knowing in what contexts (for which purposes and for which audiences) to use text, images, sound, video, or combinations of media. At the same time, these options enable students for whom one medium may be a barrier to find a more effective and engaging medium for their purpose.

In support of *affective learning*, a UDL curriculum provides *multiple means of engagement*. This recognizes the centrality of motivation in learning and the individual differences that underlie motivation and engagement. Offering a choice of content and tools, providing adjustable levels of challenge and support, offering a variety of rewards or incentives, and offering a choice of learning context are effective strategies to support affective learning. Of course, there is no single solution to the problem of engaging students because of individual differences—there are many different reasons for

students' lack of engagement. Students with disabilities, as usual, highlight the issues. The same design that would likely engage a student with Attention Deficit Hyperactivity Disorder (a high degree of novelty and surprise, for example) would be absolutely terrifying (and thus disengaging) to a student with Asperger's Syndrome or autism, for whom predictability is paramount.

| Principles of Universal Design for Learning |
|--|
| Principle 1: To support <u>recognition learning</u> , provide multiple, flexible methods of presentation |
| Principle 2: To support <u>strategic learning</u> , provide multiple, flexible methods of expression and apprenticeship. |
| Principle 3: To support <u>affective learning</u> , provide multiple, flexible options for engagement. |

Figure 1. Source: Rose & Meyer (2002)

As a fundamental component of the learning environment, instructional media can tremendously impact how a student fares. Because printed text, images, and speech make unique demands on learners, different strengths and needs may surface depending upon the medium that a student encounters (Rose & Meyer, 2002). In a UDL curriculum, teachers consider the instructional media during the evaluation of ability. Rather than retrofit inflexible materials, the flexibility and interactivity inherent in digital media provide the basis for more flexible educational designs that can anticipate students' different experiences of instructional media. A UDL curriculum provides a rich enough set of options to optimize every student's learning.

Universal designs reflect a more articulated understanding of learning and contextualize presentational environments (like books and lectures) in a broader palette of truly instructional environments where students are consistently supported in learning how to learn—mastering skills and strategies, not merely consuming information. Individualizable challenges and supports are built into every element of the curriculum and every learning experience. Skill-development materials, for example, can be designed to provide built-in models of performance, opportunities for supported practice, immediate feedback, and extended communities of practice (Dalton, Pisha, Coyne, Eagleton, & Deysher, 2001). In that respect, these new environments more closely resemble traditional models of apprentice learning than book-learning (Meyer & Rose, 1998). A teacher in a large classroom will be able not only to model a process for a student but to provide the kind of customized attention necessary to maximize a student's progress, delivering personalized feedback, practice, and scaffolds.

All of these methods are facilitated and enriched by the use of digital materials and tools (Meyer & Rose, 1998; Rose & Meyer, 2002). Teachers can expand their options for presenting information, for student expression, and for engaging students by assembling

a variety of different software tools, digital content, and World Wide Web resources. Even now, new media and electronic tools are being used to construct curricula with the built-in flexibility to support differences in recognition, affect, and strategy.

UDL and Assessment: Improved Accuracy and Instructional Relevance

Print-based assumptions and practices underlie traditional assessments, making them especially inaccurate for students in the margins. A very big problem with traditional assessments is that students' capabilities with the learning task are often confounded with their ability to use the medium of assessment: "Traditional assessments tend to measure things that teachers aren't trying to measure (visual acuity, decoding ability, typing or writing ability, motivation), thus confounding the results and leading us to make inaccurate inferences about students' learning" (Rose & Meyer, 2002, p. 143). Because the expressive medium used for an assessment can influence performance independent of students' knowledge of the content or a skill (Russell & Haney, 1997, 2000), evaluation must be sensitive to its true purpose, and to the strengths and weaknesses of the learner that may not be germane to the learning being assessed. For example, the creative expression or knowledge gained by students with motor difficulties will not be accurately evaluated via handwritten assessments. For another, the acquisition of content knowledge in social studies or mathematics will not be measured accurately on a print-based multiple choice test for a student with decoding difficulties. A more flexible approach is needed not only to improve the accuracy of assessments for students on the margins but also to enhance the meaningfulness of assessments for all students:

Technology also offers the opportunity to assess skill learning in a deeper and more meaningful way. For example, science students might conduct virtual lab experiments, in which their actual manipulations of data, technologies, and substances would demonstrate their understanding of processes, methods, and outcomes more clearly than any written or verbal responses could (Rose & Meyer, 2002, p. 148).

Universally designed assessments will also gain accuracy from the capacity to evaluate performance under varying conditions—ranging from conditions where the student's performance is constrained by barriers inherent in specific modes of representation, expression, or engagement, to conditions where appropriate adaptations and supports are available to overcome those barriers. In this manner, it will be possible to identify with more specificity the source of difficulty for a student, yielding more effective measures of student performance and the learning process underlying that performance.

Another problem with traditional assessment is that the *outcomes* of learning are measured—the number of science facts recalled, the percentage of words spelled correctly—rather than the *processes* of learning. Such traditional outcome measures

are poorly-designed and ill-timed to inform instruction. In contrast, the interactive capacity of new technologies allows us to embed assessment dynamically within instruction—providing an enhanced basis for curriculum-based measurement and progress monitoring practices that have been linked to improved instructional decision making and student performance (Espin & Foegen, 1996; Fuchs, Butterworth, & Fuchs, 1989; Fuchs, Fuchs, & Hamlett, 1989; Fuchs, Fuchs, & Stecker, 1989). By tracking what supports a student uses, the kinds of strategies that he or she follows, the kinds of strategies that seem to be missing, and the aspects of the task environment that bias the student toward successful or unsuccessful approaches, the teacher gains information about students as learners. Embedded UDL assessment provides timely information that can inform teaching, and differentially for each student. It also ensures that students have available the same supports during assessment that they have during learning.

UDL Applied: A Research-Based Learning Environment

An example of a UDL environment with built-in flexibility for instruction, learning, and assessment is that of Thinking Reader, a computer-based, networked program designed to improve reading comprehension (Dalton, et al., 2001). Developed by CAST over several years in federally funded research projects, Thinking Reader combines the research-supported techniques of strategy instruction and reciprocal teaching (Palincsar, 1986, 1998; Palincsar & Brown, 1984) with versatile technologies. The Thinking Reader prototype—which has been developed and commercially distributed for classroom use by Tom Snyder Productions—consists of digital versions of high-quality children’s literature embedded with tools and prompts that can be adjusted to respond to learner differences in decoding, comprehension strategies, vocabulary knowledge, visual acuity, and many others. Age-appropriate, appealing literature with supportive features such as text-to-speech capability; built-in logs for monitoring progress; flexibility in visual or oral presentation of text—these all ensure that students are supported and prepared to learn.

In such an environment, they are ready to learn effective strategies for active reading and individualized strategy instruction is delivered through prompts embedded within the text, and models and hints offered by animated characters. The prompts ask students to apply one of multiple, research-supported strategies: predict, question, clarify, summarize, visualize, describe your personal reaction, or reflect on your progress. These prompts are leveled so that teachers and students can select the degree of challenge that best supports progress. The results of controlled experiments show that Thinking Reader was superior to traditional strategy instruction in elevating reading comprehension for middle school struggling readers (Dalton, et al., 2001). More recent work focuses on improving results in the same way for students with cognitive disabilities (Literacy by Design, Dalton, B., & Zeph, L., 2003, with the University of Maine) and students who are English Language Learners (Thinking Reader for English Language Learners, Dalton, B., 2003).

Conclusion: Students in the Margins, Technology, and Educational Reform

Innovations in educational technologies are driven by the needs of students in the margins, those for whom present technologies are least effective—for example, students with disabilities or exceptional talents. These more conspicuous needs highlight the curriculum's failings. However, as new technologies help us to appreciate the full extent of learners' diversity and the variety of ways in which they can be unique, it will become apparent that the curriculum itself can be improved to the benefit of all students.

This will require a significant change in mind-set about the possibilities of new technologies for education and ultimately about our educational goals. There is understandable resistance to change, as entrenched approaches to curriculum design, assessment, teaching, and even the structure of schools and classroom practices are firmly rooted in the venerable and powerful traditions of printed text. While the hegemony of this medium has already disappeared in such high-impact fields as advertising, entertainment, and communication in the culture at large, the legacy of print continues in schools. While computers offer tremendous power for learning with text, their capacity reaches well beyond text to facilitate teaching and learning with varied media and to offer customizability. Yet by analogy with film, we are still in the era of the camera sitting on a stage and filming from one angle, basing our assumptions on one set of goals, tools, methods, and assessments that is expected to—but does not—work for all learners.

Students in the margins must be served, and the technology is here now to serve them effectively. UDL—including its framework and tools for learning—transforms the pressures of diversity into opportunities for all learners because it does not resist diversity, as traditional curriculum centered around printed text does—insisting that all learners “fit the mold.” Rather, UDL recognizes the fact that diversity in learning abilities and styles can be a tremendous asset if we are willing to reconsider the way curricula are designed and the way schooling is practiced from the “margins” perspective.

Of course, such a change will inevitably result in changed goals. The implicit goal of education will change from homogenization (all students pointed toward one outcome and measured by one yardstick) to diversification, identifying and fostering the inherent diversity among all learners, identifying new kinds of learning, new kinds of teaching, and new kinds of success. The ultimate educational goals will no longer be about the mastery of content (content will be available everywhere, any time, electronically) but about the mastery of learning. At commencement, we will graduate students who are “expert learners.” They will know their own strengths and weaknesses; know the kinds of media, adaptations, strategies, and external technologies they can use to overcome their weaknesses and extend their strengths; and know what kinds of colleagues are likely to complement their own patterns of learning and performance. They will be

prepared for a changing world, not a static one—prepared for the world in which they will actually live. As in any revolution, students in the margins are likely to lead the way, precipitating the shifts in thinking that will open vast opportunities for educational reform. They have much to offer in this enterprise; we all have much to gain.

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