UNIVERSAL DESIGN FOR LEARNING: BENEFITS FOR ALL WHEN DESIGNING FOR ALL

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Abstract

Universal Design for Learning (UDL) uses inclusive instructional strategies that benefit a broad range of learners. UDL is based on the principles of *Universal Design* originating from the field of architecture and adapted and extended for applications in education and learning. Although intended primarily to serve students with disabilities, UDL concepts apply to all learners if one accepts that all people have their own unique differences, some of which are well aligned with mainstream educational practice and some that are not. While UDL is embraced by special educators and others who work with people with disabilities, its principles and tenets apply well to all learners. UDL is inherently about access with the goal to create learning materials and opportunities that reach the greatest number of people possible without the need to design and develop multiple lessons or activities. Rather than constantly redesign instruction, the goal is to design flexibly, taking full advantage of the affordances of digital media. As a field, instructional technology is well known for its integration of research, theory, and practice. Unfortunately, the field of Instructional technology has not played a significant role thus far in the evolution of UDL, despite its history and expertise in design. But, the UDL movement is still in its infancy, at least as it relates to applications to learning and teaching. The field of instructional technology is well poised to make a significant contribution. The best research emerging from instructional technology and the learning sciences can be used to further extend the UDL framework to address the concept of “learning access” for all people. For example, task-centered approaches to designing instruction as well aligned with UDL. Several examples are offered to demonstrate UDL in action, including a project recently begun at the University of Georgia where mobile technologies are used to help young adults with intellectual disabilities become more independent in the community.

Introduction

People who are denied access to education are being discriminated against in one of the worst ways imaginable. Education is a doorway to opportunity, personal growth, and economic independence. But, merely gaining physical access to education, whether the context is a school, training facility, or an online course, is not enough. The diversity of people and their learning needs require educational approaches that are likewise diverse in order to accommodate them. The field of instructional technology has been a champion for diversity in many respects, given that its researchers and practitioners have focused on helping people within a wide range of learning contexts (e.g. K-12 schools, post-secondary education, corporate training, military training, and informal learning). People in the field of instructional technology are well known for being leaders in the design of learning environments that take full advantage of technological innovations based on what we know about how people learn (cognition) and why (or why not) people want to learn (motivation). It is somewhat surprising then that the leading scholars of instructional technology have largely ignored the issue of how to provide equal access to learning and education to people with disabilities.

This paper presents an overview and brief history of Universal Design for Learning (UDL) (Rose & Meyer, 2000, 2002), and suggests an important role for instructional technologists to play in it. It is argued that UDL is an excellent candidate for an instructional design framework within which the very best practices and ideas resulting from the past 30 years of research in instructional technology and the learning sciences can be organized and applied to all people equitably. Examples and implications of UDL principles for instructional design practice are provided. Finally, a new project just begun at the University of Georgia, funded by the United States Department of Education, titled “iSkills,” is discussed as an example of UDL with mobile technologies.

Background

The principles of UDL were developed at the Center for Applied Special Technology (CAST.org). UDL was inspired by, and is a special case of *Universal Design*, a movement begun in architecture to make physical space accessibility to all people regardless of the physical disabilities they might have. Although UDL differs in considerable ways from universal design, it is important to understand the historical connection between the two and the fundamental principles they share. For example, when accessibility is considered at the beginning, there is no need for expensive and clumsy retrofitting for later use by people not served well by the original design. It’s useful to first consider the implications of this principle in architecture. For example, consider the need for a person in a wheelchair to enter a large government building built many years ago. It is likely the person will be confronted with dozens of steps leading to huge and heavy front doors. The person would need to be carried up the stairs, which could be quite humiliating. The person would need to be helped again to open and pass through the doors. Buildings such as these that are later retrofitted with a wheelchair ramp often require the ramp to be in the back of the building due to space limitations. Having to enter at the back of the building is likewise humiliating due to the way it creates a second-class facility for a segregated group of people.

The term “universal design” was coined by the late Dr. Ron Mace, a pioneer in accessibility who was a professor of architecture at North Carolina State University until his death in 1998. Dr. Mace defined universal design as the “…design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (http://www.design.ncsu.edu/cud/univ_design/ud.htm). Furthermore, universal design is “…a sensible and economical way to reconcile the artistic integrity of a design with human needs in the environment. Solutions which result in no additional cost and no noticeable change in appearance can come about from knowledge about people, simple planning and careful selection of conventional products” (Mace, Hardie, & Place, 1991). Buildings based on universal design principles bridge the gulf between function and aesthetics. A classic example is the Louvre Pyramid in Paris designed by I.M. Pei.

As a result of these efforts begun in architecture, the concept of universal design spread to many other areas of public and private life, from environmental initiatives, recreation, and the arts, to health care and now to education. In many ways, meeting the rights of people with disabilities is a civil rights issue, and could be considered as the latest phase of the civil rights movement in the United States. For example, here are some of the critical milestones of the history in the United States guaranteeing the rights of people with disabilities:

- In the 1950’s, the needs of disabled veterans focused attention on the barrier-free movement;
- Beginning in the 1950s, the civil rights movement supported the creation of anti-discrimination laws;
- In 1961, the American Standards Association published the first barrier- free standard entitled, *A 117.1-Making Buildings Accessible to and Usable by the Physically Handicapped*;
- In 1984, the Uniform Federal Accessibility Standard (UFAS) was created from the various State-adopted standards;

- In 1990, the Americans with Disabilities Act was passed into law.

It is important to note that the proportion of people with disabilities, physical and intellectual, is roughly the same among the populations of all countries worldwide. For example, the percentage of people with a developmental disability has been approximately 1.5% of the population throughout the history of humankind. This was so among all ancient civilizations, such as Roman, Greek, Chinese, and Arabian, and remains so today in towns and cities throughout the world.

The core principles of universal design are as useful to an architect designing a modern office building as they are to a software designer creating a new app for a smart phone:

- The design should be *equitable* so that no particular group of people is restricted in its use;
- The design should be *flexible* to allow different people with different needs to use it with similar success;
- The design should be *simple* and *intuitive* to use;
- All needed information and functions should be readily *perceptible*;
- The design should be highly *tolerant of user error*;
- The design should require *low physical* effort; and
- The *size and space* of the design should allow people with different physical attributes to *approach and use* the design.
  (Adapted from http://www.ncsu.edu/www/ncsu/design/sod5/cud/about_ud/udprinciplestext.htm)

Another core principle shared by universal design and UDL is that people for which the original design was *not* intended benefit, sometimes in surprising and unexpected ways. The classic example is curb cuts, those notches with small ramps built strategically into sidewalks leading down those critical few inches to the street level. Although designed to help people with limited mobility navigate a city's streets, such as a person in a wheelchair, this design benefits anyone who is pushing a heavy cart, pulling a wagon, or hauling a heavy suitcase on wheels. Another example is those who benefit most from closed captioning on television. Although intended originally for people with a hearing disability, the main beneficiaries are people trying to follow a sporting event in a noisy cafe, or a couple where one partner likes to watch television in bed while the other sleeps. Closed captioning is also an instructive example where the cost of retrofitting is very expensive. When built in to the television, the electronic chip that makes closed captioning possible costs about one U.S. dollar per set during production, whereas retrofitting a television costs several hundred dollars.

Why Practice Universal Design for Learning?

There are four good reasons to practice UDL. The first reason, and best, is that it is the right thing to do. Placing individuals at the center of our design planning who are traditionally at the margins of society, then working progressively outward to those individuals most usually accommodated, is an ethical and moral position to take as instructional designers. But, UDL goes much further than defending the practice solely on ethical and moral grounds and this leads to the second reason to practice it: doing so leads to better instructional designs for all people, both those with and without a disability. Taken together, these two reasons form the thesis of this paper.

However, if you find the first two reasons to practice universal design not to be persuasive enough, there are at least two other reasons to consider. Reason three is that if you support a design movement focused on UDL, then you might find yourself eventually as the beneficiary. As people grow older, they are likely to eventually find themselves developing a disability that will impair them in ways that must be accommodated. In the United States, one person in five has a disability, "…making people with disabilities the largest minority group and the only group that anyone can join at any time: at birth or through an accident, illness, or the aging process" (http://disabilityisnatural.com/).

Based on data collected from the National Health Interview Survey in the United States during 1997-2007 involving over 18,000 people aged 50-64 years, people reported increased mobility-related problems as they age, such as grasping small objects, stooping, bending, and reaching overhead. Other data, such as that from the 1990 United States Census, demonstrate the strong relationship between aging and disability. By the time Americans reach the age of 65, these data show that 70% will have a disability of some sort, with 25% having a severe disability (http://codi.buffalo.edu/graph_based/.demographics/.awd/AWD.html). Most the people reading this paper will need, and expect, some accommodations in their lifetime.

If you are still yet unconvinced, then the fourth reason to practice UDL, at least at the level of physical access, is that it is required by most state and federal funding agencies in the United States for materials generated by the project and disseminated to the public. I do not know the degree to which this is a requirement internationally, but I suspect it will at least be a growing trend among government funding agencies worldwide. Private funding agencies are likely to follow suit.

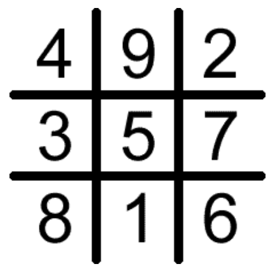
Actually, by acknowledging the diversity of people is another way of saying we are all "disabled." Consider the personal strengths and weaknesses of you and your closest group of family, friends, and colleagues. Each person has their own unique abilities, accompanied by their own shortcomings. The composition of an instructional development team presupposes that each member brings unique contributions to the effort along with the corollary that not all team members share the same strengths. Indeed, one of the unique skills of the project manager is to leverage these individual contributions into a collective and cohesive working group, much like the conductor of an orchestra is able to harness the talents of the individual musicians to perform a symphony. Howard Gardner's (1993, 1999; Moran, Kornhaber, & Gardner, 2006) well-known theory of multiple intelligences is completely aligned with this point of view. This theory purports eight distinct intelligences: Linguistic (word smart), logical-mathematical (number smart), spatial (picture smart), bodily-kinesthetic (body smart), musical (music smart), intrapersonal (self smart), and naturalist (nature smart). Learning environments that focus predominately on just a few intelligences, such as public school's preoccupation with linguistics and mathematics, can lead individuals whose strengths lie elsewhere to believe that they are not intelligent and that they cannot be successful.

Amusingly, evidence of an average person's "disabilities" can be found everyday. To use a simple and personal example, I was in the grocery store recently to purchase toothpaste. Like most people, I prefer a certain type. However, the different brands and varieties of toothpaste available in the average American grocery store are staggering: The shelves with toothpaste at my local grocery extend about five feet high and 10 feet long. I returned home with the wrong toothpaste, having been unable to sufficiently discriminate between the choices available. How many times have you "failed" at a similar everyday task? The grocery store is actually a very interesting "laboratory" to explore visual and organizational design. One might argue that it is in the interest of the grocery store owner to keep as many distractions and obstacles as possible facing the consumer because that might lead the shopper to purchase a more expensive item or tempt the shopper to purchase items that are not really needed. Imagine the difficulty in a grocery store faced by persons with either decreased ability to visually discriminate or focus attention. If the principles of universal design were practiced in the grocery store, everyone would benefit.

One of the longstanding findings from my own research on the design of multimedia is that the way a problem is represented matters great to learning (Rieber, 1995; Rieber, 1996). Two illustrative examples that make this point well. The first example is a simple game played by two players (Norman, 2002). Each player, in turn, selects a card numbered one to nine to their side of the table. A number can only be chosen once and only by one of the players. The winner is the first player with any *three* cards that sum to 15.

If this game seems vaguely familiar to you, it is because it is actually a numerical version of the children's game called tic-tac-toe (also known as "naughts and crosses"). However, most people are familiar with the visual version of the game where the two players take turns drawing an X or O on a 3 X 3 grid. If the digits from 1-9 are specially arranged on this grid, as shown in Figure 1, then any row, column, or diagonal sums to 15. Interestingly, useful strategies in the visual representation, such as choosing the center cell, transfer well to the numerical version (i.e. selecting the number 5).

Figure 1. The children's game of tic-tac-toe with the digits 1-9 superimposed on it to form a magic square where all rows, columns, and diagonals sum to 15.



Of course, most adults do not play tic-tac-toe because they learned long ago that the game always ends in a tie, making the game very boring. However, even when people know the "secret identity" of the numerical version, it remains a challenge to play and win. Even though the rules of the two games are identical, the way the game is represented makes all the difference.

The second example comes from mathematics. For example, I challenge you to explain the following mathematical equation:

$$\int dx = x$$

Few people who have not studied advanced mathematics are able to do so. Many people also becoming anxious just at the request to try. People who say they are "not good at mathematics" are likely just victims of learning with representations that poorly match their learning needs. For example, consider the simplest of mathematical expressions, such as "4 + 3 = 7". There is no inherently meaningful connection between two small lines crisscrossing each other and the mathematical idea of "add together." The advantage in using this arbitrary symbol is its economy of expression. However, this economy is only as useful as the ability of people to learn it.

So it is with the mathematical equation " $\int dx = x$ ". The symbol x represents any quantity and the symbol "dx" represents the tiniest imaginable fraction of x. Everyday words and phrases such as "tiniest bit," "tad," or "morsel" do not come close to the small quantity that dx represents. Instead, dx simply represents the idea of an infinitely small amount. So, we might practice a thought experiment where we think of a cookie as x and divide the cookie over and over and again in our heads, knowing that no matter how small the crumb becomes, dx is always smaller. The symbol $\int$ simply means "the sum of." So, if we sum up all of the smallest bits of the cookie we end up with a whole cookie. That is not too hard to understand. These ideas are the core of differential and integral calculus, ideas which are crucial to understanding any phenomenon involving rates of change. Rate of change problems confront us everyday (ask anyone who has ever tried to lose weight). Most people who are not able to learn calculus likely fail not because they lack the intellectual capacity to understand the ideas, but rather because of the way the problems are represented. This example illustrates the difficulty many people have with so much of formal learning.

The Emergence of Universal Design for Learning

UDL differs from universal design in that UDL focuses exclusively on issues of education and learning. It is a set of principles and design guidelines, based on research, that comprise a framework to use technology in practical ways to help every student take full advantage of learning opportunities. Simply put, UDL is a way to conceptualize and describe good design, but one that begins with the needs of people usually viewed at the margins of society.

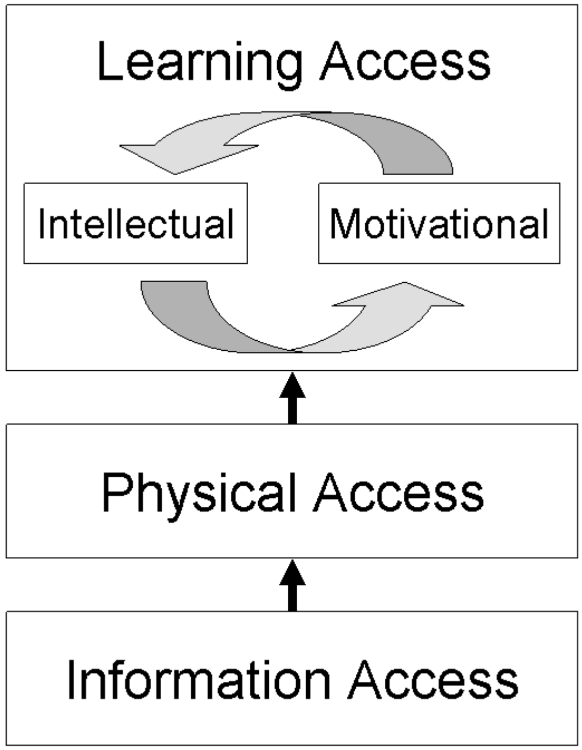
In the United States, the Individuals with Disabilities Education Act (IDEA) of 1997 guarantees that students with disabilities have a right to the same educational opportunities as anyone else. As such, schools and teachers are responsible for ensuring that students with disabilities are given equal access and make adequate progress in all aspects of the school curriculum. Of course, as the diversity of students in the classroom increases, so does the challenge to educators to meet these needs. Rather than provide a curriculum and teaching methods in a "one size fits all" model, allowing significant numbers of students to either fail or be disenfranchised, the UDL model takes advantage of technology to provide customized learning opportunities for all students. This is similar to other efforts, such as differentiated instruction (Lynch & Warner, 2008), but with the difference that UDL begins with the needs of those with special needs. Digital technology is an inherently flexible medium and UDL capitalizes on this flexibility. For example, information encoded digitally can be physically delivered in multiple ways, such as converting text to voice, with little or no extra work on the part of the teacher or designer. Even the simple ability of the computer to alter the size of text or images on the screen is a powerful tool for accommodating the needs of people with visual impairments. But, even as important as these physical accommodations are, they represent a small fraction of the potential of UDL to meet the needs of diverse learners, with or without disabilities. For example, traditional practice exercises presented by the computer can be programmed to quickly adjust the difficulty level of the activity based on the student performance. More recently, the state-of-the-art of computer gaming and simulation provides unprecedented opportunities for providing differentiated learning materials. An important assumption of UDL is that "barriers to learning are not, in fact, inherent in the capacities of learners, but instead arise in learners' interactions with inflexible educational materials and methods" (Rose & Meyer, 2002, p. vi).

UDL = Physical Access + Learning Access

If one word could sum up UDL it would be *access*. Interestingly, designers in the United States have become more much aware of accessibility standards as the Internet has become the principal means of delivering educational multimedia. For example, the growth of distance education delivered through the Internet (i.e. eLearning), has been made possible largely through increased capacity of the Internet's bandwidth. This has allowed distribution of content beyond text and simple graphics, such as audio, animation, and high-quality video. For many designers and developers, however, accessibility has only been equated with providing alternatives forms of this content, such as providing ALT tags for graphics in Web pages, text captioning of audio content, and making sure that screen readers can interpret Web pages for people with visual impairments (e.g. using CSS instead of tables for screen formatting). Yes, this is a good place to start designing for accessibility, but it falls far short of addressing the full range of accessibility needs.

Figure 2 illustrates the range of accessibility levels. It begins with a person's access to information. People who have limited access to basic information and services, whether these are from government, employment, or education, will likewise have much fewer opportunities to reach their full human growth potential. One obviously needs access to a computer and an Internet connection in order to access the information available on the World Wide Web. It is often said that half the world has yet to make a phone call, a statement which aptly summarizes the lack of access to even the most basic technology. The difference of access between the most and least privileged in society is often referred to as the "Digital Divide" (DiBello, 2005; National Telecommunications and Information Administration, 1998; Warschauer & Matuchniak, 2010).

Figure 2. Levels of Access.



However, if we begin with the assumption that the user at least has access to the Internet, then the next level of access is physical access. This is the aim of most accessibility standards and is the easiest form of accessibility to attain given that it is largely only a technical challenge to overcome assuming the design team chooses to do so. The challenge to meet these accessibility standards is relatively easy and inexpensive to achieve when it is considered from the very beginning of a project. In contrast, the challenge to comply with physical accessibility standards grows in complexity and difficulty if accessibility is ignored at the start. As already mentioned, retrofitting an existing design to meet accessibility standards can be a very expensive task.

The next level is access to learning and this is where the ideas and influence of UDL are most strongly felt. Not coincidentally, it is also the place that instructional technologists have the most to offer. Learning access is a combination of intellectual access and motivation – a person has both the intellectual capacity to understand the learning content while also desiring to do so. As the calculus example above suggests, intellectual capacity is very dependent on the way the content is represented.

Method

So, how does one practice Universal Design for Learning? The first step is the simplest, but perhaps the most important: Begin by making a commitment to do so on every instructional project you begin. The second step is to plan the design to meet both physical accessibility standards and learning accessibility standards. To use an adaptation of the quote by Dr. Ronald Mace cited above, the team should take on an attitude that their project will be usable by all students to the greatest extent possible. The third step is to begin all design conversations from the point of view of persons with disabilities who will use the materials. This includes all people with a formally diagnosed disability, but also those who would be “disabled” by poor design.

Part of these conversations should also acknowledge ways in which other people will benefit from these design accommodations. For example, a design project that will contain animations of important principles, such as the physical relationship between acceleration and velocity, should include narrative explaining the animation from the point of view of someone who cannot see the animation. Rather than consider the writing of such a narrative as a nuisance, the design team should see the task as an opportunity to give a valuable extra resource to those students who can see the animation. My own early research on animation from the 1990s demonstrated that students often failed to “see” the important relationships depicted in the animation. That is, they watched the animation, but they often failed to recognize the principles demonstrated by the animation (Rieber, 1989, 1991). These students would benefit from having these important principles deliberately and carefully pointed out and explained with text or audio (Mayer & Anderson, 1992).

A good example of how providing a verbal description benefits everyone is the New York Beyond Site project (http://www.nybeyondsight.org/) where prominent New Yorkers describe their favorite places and landmarks in the city, such as the Brooklyn Bridge and the Apollo Theater. Not only does this make New York’s visual culture available to those with visual impairments, but it also greatly enhances the experience for people who can see. As described on the Web site, a verbal description is “a way of using words to represent the visual world. It helps people who are blind or visually impaired to form mental images of what they cannot see, and provides a new perspective for people with sight.”

Given that meeting physical accessibility standards is largely technical in nature, the design team should use and follow a basic checklist of attributes the project must meet. Such a checklist would include items such as the following:

- All graphics will have alternative text (e.g. ALT tags or D tags).
- All animations will be accompanied by text or audio that explains the dynamics of the animation in narrative form; similarly, all video will be accompanied by a verbal description of the visual information in the video.
- All electronic resources (e.g. Web pages) will be compatible with state-of-the-art screen readers (e.g. use of CSS instead of tables for screen formatting; table use restricted to presentation of tabular data with appropriate row and column header information provided).
- All audio tracks will be accompanied by closed captioning or other forms of a textual script of the audio.

Accessibility web sites that focus on physical access should be consulted in order to determine if other specific items to be included on whatever final checklist the team uses. Here are a few good examples:

http://www.section508.gov/
http://www.w3.org/WAI/
http://validator.w3.org/
http://www.adobe.com/accessibility/

Discussion

UDL Meets Instructional Technology: Providing Learning Access to all People

Meeting the standards for physical access to educational materials is a fairly straightforward technical endeavor. Far more difficult, but much more interesting from a design perspective, is how to meet the standards of learning access. This is the primary goal of contemporary UDL research and practice.

The long history of research in instructional technology and the learning sciences (IT/LS) also seeks to provide learning access to learners, even though it is not framed this way in the literature. The irony is that this literature rarely included special populations within their research traditions.

However, researchers have focused their efforts on understanding how people learn given access to the wide range of technological innovations. As a result, the best of these respective literatures provides very significant and very appropriate guidance on meeting standards of learning access. Time has come to merge the mission of the UDL and IT/LS research efforts.

The two research literatures offer different, but complementary approaches. For example, UDL is strongly influenced by brain research, such as that described by Cytowic (1996) (cited in Rose, Harbour, Johnston, Daley, & Abarbanell, 2006). This research suggests three interdependent cognitive networks that are needed for learning: Recognition, strategic, and affective. Recognition networks work to help an individual to sense, recognize, and interpret information in order to assign meaning to patterns from the stimuli being received. Strategic networks help the individual to plan, execute, and monitor actions and skills appropriately based on recognized information. Affective networks lead to engagement and the formation of emotional connections to our perceptions of the world. Table 1 lists the three design principles of UDL, each based on one of the three cognitive networks (Rose et al., 2006; Rose & Meyer, 2002).

Table 1. The Principles of Universal Design for Learning

- Recognition Principle: Provide Multiple Means of Representation
    - Perception
    - Language and symbols
    - Comprehension

- Strategic Principle: Provide Multiple Means of Action and Expression
    - Physical action
    - Expressive skills and fluency
    - Executive function

- Affective Principle: Provide Multiple Means of Engagement
    - Recruiting interest
    - Sustaining effort and persistence
    - Self-regulation

In contrast, the IT/LS literature is based in psychology, not neurology, but the parallels are easy to spot. The literatures on multimedia learning (Mayer, 2001, 2005; Mayer & Anderson, 1992; Rieber, 1990, 1994) and multiple representations (Ainsworth, 1999; Ainsworth, Bibby, & Wood, 2002; Moreno & Duran, 2004) are aligned with the recognition principle. The constructivist literature related to project-based approaches to learning has obvious relevance to strategic principle (Blumenfeld et al., 1991). The vast motivational literature, with Keller’s ARCS model as a prime example (Keller, 1983, 2008), is relevant to the affective principle.

First Principles of Instruction

Describing an adequate comparison between the UDL and IT/LS literatures is outside of the scope of this paper. However, this point can be made well by considering the recent work of David Merrill, a pioneering researcher, thinker, and practitioner in instructional technology. Merrill reviewed successful models of learning and instruction across the IT/LS literatures and generated a surprisingly short list of principles found common to all. Consequently, Merrill labeled these as “first principles of instruction” due to their foundational nature:

> Principle 1 - "Task-centered approach - Learning is promoted when learners are engaged in a task-centered approach, which includes demonstration and application of component skills. A task-centered approach is enhanced when learners undertake a progression of whole tasks.)” (M. D. Merrill, Barclay, & van Schaak, 2008, p. 174)

> "Principle 2 - Activation: Learning is promoted when relevant previous experience is activated." (M.D. Merrill, 2002, p. 46)
>
> "Principle 3 - Demonstration (Show me): Learning is promoted when the instruction demonstrates what is to be learned rather than merely telling information about what is to be learned." (M.D. Merrill, 2002, p. 47)
>
> "Principle 4 - Application (Let me): Learning is promoted when learners are required to use their new knowledge or skill to solve problems." (M.D. Merrill, 2002, p. 49)
>
> "Principle 5 - Integration: Learning is promoted when learners are encouraged to integrate (transfer) the new knowledge or skill into their everyday life." (M.D. Merrill, 2002, p. 50)

What is most compelling is the way that these principles seem to capture the best ideas from a wide range of epistemological positions, from behavioral to constructivist. For example, these principles capture well design models leading to robust tutorials as well as those leading to microworlds, simulations, and games. The first principle, underscoring the importance of task-centered approaches, is aligned well with the constructivist notion of a microworld. A microworld is best defined by diSessa (2000):

> A microworld is a genre of computational document aimed at embedding important ideas in a form that students can readily explore. The best microworlds have an easy-to-understand set of operations that students can use to engage tasks of value to them, and in doing so, they come to understand powerful underlying principles. You might come to understand ecology, for example, by building your own little creatures that compete with and are dependent on each other. (p. 47)

This implies there are different starting points for learners and different learning paths when working with a microworld. Students with varying abilities and interests can engage in a microworld and have an engaging and meaningful experience with it, even if each student effectively has a *different* experience. The microworld itself is able to accommodate these differences without design changes – it is flexible to allow such varied learning paths. The current interest in gaming mirrors these design attributes in the way that a game allows a user to enter with little or no content knowledge, and then progress to the most sophisticated levels of intellectual understanding. What is required on the part of the learner is an intense interest in engaging with the game (Rieber, 2005).

The iSkills Project: Supporting Young Adults with Intellectual Disabilities to Live Independently in the Community

I end this paper with a short description of a project recently begun at the University of Georgia, called iSkills. The purpose of the iSkills project is to help young adults with mild to moderate intellectual disabilities to learn critical life skills so that they can successfully transition from school to independent living. To accomplish this, we are building a video repository of essential life skills that will be delivered primarily to these individuals with mobile technologies, such as smart phones (e.g. iPhone).

Among the domains we will target include independent living, employment, safety leisure, and community involvement. Examples of these life skills include those everyday tasks that most people take for granted. The skills encompass all facets of daily living, such as how to make one's bed, doing the dishes, doing the laundry, and how to cook a meal, such as that shown in Figure 2. These skills also include navigating public spaces and social skills, such as interacting with people throughout the community.

Figure 2. Illustration of using a mobile device to assist in an everyday task.

The target audience are those individuals who are about to graduate from high school to make the transition from a school-supported and family-supported model to a community-supported model of living. Despite important legislative and societal gains over the past 50 years, people with disabilities are far from being accepted members of society. As Wells, Sandefur, and Hogan (2003) state: “For these individuals, having a disability has prevented them from achieving any of the statuses that are associated with the early transition to adulthood” (p. 826). Educators have the complex task of preparing students to be self-sufficient after graduating from high school (Lerner & Brand, 2006), but it is not impossible with the right instructional interventions.

Mobile technologies, such as the Apple iPhone, offer the potential to radically transform the way important resources are accessed by people with disabilities moment-to-moment and day-to-day. The recent and rapid increase of technological power and capabilities of mobile technologies is staggering. The iSkills project will focus on two development activities simultaneously. First, the project will produce an initial library of video clips showing the performance of critical life skills. The videos will be short (30-90 seconds each) to allow them to be viewed when and as needed in authentic situations. Once this initial library is produced, the project will form a community of practice allowing others (e.g. other university design teams, school districts, care providers, and even just individual parents and teachers) to add to the video library. All members of this community will have the option of reviewing and rating the videos in the library in order to assure appropriate quality and the meeting of essential needs. Furthermore, the community can request additional videos to be produced.

Second, the project will design a smart phone “app” (i.e. application) to allow these mobile devices to access the videos just when and where the person needs it. These videos can be used as part of direct instruction by teachers in schools as well as in self-instructional ways.

To illustrate the potential of delivering life skills videos in this way, consider the following scenario:

> Thomas, a young man with autism, is preparing for his day with help of care providers who live with him. The day’s schedule is planned, which includes doing some grocery shopping, returning some books at the library, and doing some volunteer work at a local restaurant. After reviewing the schedule, Thomas and his care provider dock his smart phone into the computer and access the iSkills web site. They download about 10 videos that will help Thomas during the day. The app also allows Thomas and his staff to sequence the videos in the general order in which they will be needed. The smart phone

syncs with the Web site, downloading the needed videos while Thomas and his staff finish eating breakfast. Thomas and his staff leave the house and walk to a bus stop. As they wait for the bus, Thomas watches a short video reminding him of the appropriate way to board the bus and pay his fare. During the day, Thomas watches similar videos as needed as he and his staff navigate the community. On this day, they decide to go immediately to the library, even though the plan originally was to go to the grocery store first. As Thomas and his staff get off the bus at the library stop, the smart phone's GPS notices they are in the proximity of the library and so it automatically puts those videos at the top of the playlist. Thomas is a few days late returning his books, so he watches a short video on how to pay for overdue fines just before they enter the library. Thomas and his staff have a great day in the community, then head home. Thomas watches other videos as needed at home as he completes his daily chores. Thomas enjoys a phone call from his sister, and then has some quiet time listening to music on his smart phone. The day ends with watching some television. Thomas prepares for bed, watching one last video on his smart phone about how to take his medications. It's been a very good day.

On one hand, the iSkills project deals with mundane aspects of life that most people simply take for granted. But for Thomas and others with developmental disabilities, many of these skills are overwhelming, especially in the context of social situations in the community. The smart phone becomes another helpful "companion," a personal assistant that these individuals can rely on all during the day.

From a UDL perspective, we are mindful that the videos and smart phone app we will be developing will have uses beyond the intended audience. Those individuals who are experiencing the onset of Alzheimer's disease would likely find the iSkills resources and approach equally useful. It's also easy to imagine other individuals to benefit from this project who do not have a disability, but simply do not know certain fundamental skills. For example, young first-year college students who are away from home for the first time and need to be completely responsible for doing their own laundry would likely find these videos very helpful.

Conclusions

Instructional designers and other educators can choose to practice UDL for many reasons. Among the most compelling is that embracing a UDL framework should lead to better and more creative designs. These designs begin from the point of view of students who have barriers – physical, intellectual, and motivational – to understanding. The best approach will likely be task-centered, such as students working together on an authentic project all find important and meaningful. The students will need to have different ways of accessing and interpreting resources. As more resources are created and delivered in digital form, the resources will be inherently more flexible in how they deliver information and engage students. The best resources for learning will be highly interactive and experiential, such simulations, games, and microworlds. These activities begin with the simplest examples of the domain, and provide flexible learning paths as students progress through them.

The field of instructional technology has a long history of developing and researching instructional design models to optimize student learning and understanding (Saettler, 1990). These models have been based on the psychology of learning and motivation coupled with the affordances of technology. Time has come to bring the best ideas from the instructional technology field to the design challenge of meeting all levels of accessibility. Instructional technologists have a lot to offer, and even more to gain, by choosing to participate in universal design for learning.

References

Ainsworth, S. (1999). The functions of multiple representations. *Computers and Education, 33*, 131-152.

Ainsworth, S., Bibby, P., & Wood, D. (2002). Examining the effects of different multiple representational systems in learning primary mathematics. *Journal of the Learning Sciences, 11*(1), 25-61.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palinscar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3 & 4), 369-398.

Cytowic, R. E. (1996). *The neurological side of neurospychology*. Cambridge, MA: MIT Press.

DiBello, L. C. (2005). Are We Addressing the Digital Divide? Issues, Access, and Real Commitment. *Childhood Education, 81*(4), 239.

diSessa, A. (2000). *Changing minds: Computers, learning, and literacy*. Cambridge, MA: The MIT Press.

Gardner, H. (1993). *Frames of mind: The theory of multiple intelligences*. New York: BasicBooks.

Gardner, H. (1999). *Intelligence Reframed: Multiple Intelligences for the 21st Century*.

Keller, J. M. (1983). Motivational design of instruction. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-434). Hillsdale, NJ: Erlbaum.

Keller, J. M. (2008). First Principles of Motivation to Learn and e[superscript 3]-Learning. *Distance Education, 29*(2), 175-185.

Lynch, S. A., & Warner, L. (2008). Creating Lesson Plans for All Learners. *Kappa Delta Pi Record, 45*(1), 10-15.

Mace, R. L., Hardie, G. J., & Place, J. P. (1991). Accessible Environment: Toward Universal Design. *[On-line]. Available: http://www.design.ncsu.edu/cud/pubs/center/books/accenviron.htm*.

Mayer, R. E. (2001). *Multimedia learning*. Cambridge, UK: Cambridge University Press.

Mayer, R. E. (Ed.). (2005). *Handbook of multimedia learning*. New York: Cambridge University Press.

Mayer, R. E., & Anderson, R. B. (1992). Animations need narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology, 83*, 484-490.

Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59.

Merrill, M. D., Barclay, M., & van Schaak, A. (2008). Prescriptive principles for instructional design. In J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer & M. P. M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (pp. 173-194). New York: Lawrence Erlbaum Associates.

Moran, S., Kornhaber, M., & Gardner, H. (2006). Orchestrating Multiple Intelligences. *Educational Leadership, 64*(1), 22-27.

Moreno, R., & Duran, R. (2004). Do Multiple Representations Need Explanations? The Role of Verbal Guidance and Individual Differences in Multimedia Mathematics Learning. *Journal of Educational Psychology, 96*(3), 492.

National Telecommunications and Information Administration. (1998). *Falling through the Net II: New Data on the Digital Divide* (No. [On-line]. Available: http://www.ntia.doc.gov/ntiahome/net2/falling.html).

Norman, D. A. (2002). *The design of everyday things*. New York: BasicBooks.

Rieber, L. P. (1989). The effects of computer animated elaboration strategies and practice on factual and application learning in an elementary science lesson. *Journal of Educational Computing Research, 5*, 431-444.

Rieber, L. P. (1990). Animation in computer-based instruction. *Educational Technology Research & Development, 38*(1), 77-86.

Rieber, L. P. (1991). Effects of visual grouping strategies of computer animated presentations on selective attention in science. *Educational Technology Research & Development, 39*(4), 5-15.

Rieber, L. P. (1994). *Computers, graphics, and learning*. Madison, WI: Brown & Benchmark.

Rieber, L. P. (1995). A historical review of visualization in human cognition. *Educational Technology Research & Development, 43*(1), 45-56.

Rieber, L. P. (1996). Animation as feedback in a computer-based simulation: Representation matters. *Educational Technology Research & Development, 44*(1), 5-22.
Rieber, L. P. (2005). Multimedia learning in games, simulations, and microworlds. In R. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 549-567). New York: Cambridge University Press.
Rose, D., Harbour, W. S., Johnston, C. S., Daley, S. G., & Abarbanell, L. (2006). Universal Design for Learning in Postsecondary Education: Reflections on Principles and their Application. *Journal of Postsecondary Education and Disability, 19*(2), 135-151.
Rose, D., & Meyer, A. (2000). Universal design for learning. *Journal of Special Education Technology, 15*(1), 67-70.
Rose, D., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. Alexandria, VA: Association for Supervision and Curriculum Development.
Saettler, L. P. (1990). *The evolution of American educational technology*. Englewood, CO: Libraries Unlimited.
Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes. *Review of Research in Education, 34*, 179-225.