UDL and Materials Science

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Abstract
The field of UDL is confused about the source of power in the intervention. That is, what are the active ingredients in an instructional design that make it universally accessible and usable? The purpose of this UDL Talk is to challenge the UDL community to consider a series of constructs that heretofore have been overlooked in conversations about designing instructional materials for diverse learners.

Keywords
universal design engineering, value chain, materials science, active ingredients

INTRODUCTION
The philosophy of UDL is relatively easy to understand: (a) It is important to design educational environments and materials to be accessible for individuals with disabilities so that they can access and engage in learning, and (b) In an increasingly diverse world, universal design is an intervention that seeks to provide direct benefit to individuals with disabilities while simultaneously offering benefit to everyone at no additional cost. Despite the intuitive appeal of UDL, in practice it has proven problematic to design, implement, evaluate, and scale (Edyburn, 2010; Edyburn & Edyburn, 2012).

Researchers have encountered similar problems. To-date, there is little research evidence demonstrating the efficacy of UDL (Edyburn, 2010; Rao, Ok, & Bryant, 2014). Particularly problematic is the inability to define what UDL is, and what it is not. Since the current definition of UDL (Rose & Meyer, 2002) involves multiple concurrent interventions (multiple means of representation, expression, and engagement), it is not possible to (a) isolate the active ingredients of this intervention cocktail to determine which components impact individual student learning, or (b) determine what dose is needed to produce successful learning outcomes. If we are to move beyond the current unfulfilled potential of UDL, new directions are needed. In the sections that follow, I summarize some of my observations.

THE STATUS QUO
If the origins of UDL can be traced to the late 1990s, we have been at this endeavor for almost 20 years. Nonetheless, there is little agreement about who the key UDL stakeholders are or what the strategic leverage points for achieving the promise of UDL are. There has been little attention devoted to ineffective design methods (i.e., ego design, design for the mean). Finally, there is little consensus about whether the design problem is simply about accessibility or engagement, thereby missing the large issue of inequitable learning outcomes (i.e., the achievement gap). Unless things change soon, I am convinced that the legacy of UDL will be a historical footnote as designers now pursue *personalized learning*, an initiative that has the potential to achieve all the goals of UDL and more.

VALUE CHAIN
A value chain is a management concept that describes the life cycle of a product from conception to end-user (Hartley, 2004). In practical terms, how does a textbook or digital learning object end up on a student's desktop? To answer this question it useful to adapt an accessibility framework (Di Iorio, Feliziani, Mirri, Salomoni, & Vitali, 2005) that describes four phases of a value chain that produce accessible educational materials (AEM): Authoring, Production, Delivery, and Use. Comparing and contrasting the development of automobiles and educational materials provides a means to understand the leverage points within the value chain.

POLLUTION
Whereas, it is relatively easy for a content designer to scan an original historical book, compile the bitmap images into a PDF, and then post the file online, the outcome of this work is what we refer to as pollution. The concept of pollution in the design of educational materials occurs when an author/ publisher distributes content that is inaccessible because they do not have the time, interest, or resources to make the information fully accessible. In essence, they are pushing the costs of accessibility into the user community.

Economically speaking, pollution costs are not borne by the producer but offset to others (i.e. teachers, students) who must commit significant individual resources to convert the information into an accessible format for their personal use. These costs are astronomical (i.e. cost for the author/ publisher to create an accessible version of a text-based digital learning materials vs. the costs of thousands of users who must convert the inaccessible file). Benetech (2015) has estimated that the cost of converting inaccessible math content is 2,500 times more expensive because the materials were not born accessible.

ACADEMIC DIVERSITY BLUEPRINTS

In order to effectively design curricula for diverse learners it is necessary to construct an academic diversity blueprint to guide instructional design efforts. That is, explicitly develop design features to support both targeted learners (primary beneficiaries) and secondary beneficiaries. The development of an academic diversity blueprint will clearly be constrained by a designer's knowledge and skills, resources, and time relative to how to implement specific interventions. Likewise, if a designer has minimal understanding of special needs, they may have reduced motivation to explore the need to introduce new features into their product design. However, concern about universal usability is a powerful motivator for designers interested in developing a product that is commercially successful. Ultimately, an academic diversity blueprint must be developed by an interdisciplinary team. The blueprint will subsequently serve as the engineering list of requirements/specifications.

ACTIVE INGREDIENTS

Technologies are often described as a black box. This pejorative comment reflects the fact that how and why something works the way it does is a mystery. In the field of special education, we cannot allow this type of thinking (e.g., a student hasn't learned his math facts, let's try using an app). We must be intentional, prescriptive, and insist on knowing why, how, and for whom an intervention will work. Researchers have referred to this concept as a need to isolate the active ingredients (Clark, 2009; Clark & Saxberg, 2012; Levac, Rivard & Missiuma, 2012; Whyte & Hart, 2003). That is, which components impact individual student learning, and in what dose they are needed to produce successful learning outcomes?

MATERIAL SCIENCE

Whereas, the evolution of printed materials in the classroom occurred over 300 years, the evolution of digital learning materials has emerged over the past 20 years. Clearly, advances in technology have altered the containers used by educators to transmit knowledge and reach larger segments of a diverse population. However, advances in technology have disrupted the traditional publishing value chain by allowing individuals to control the entire value chain of their product (e.g. self-publishing authors, independent musicians) thereby disrupting the traditional business model and power of educational publishers. This creates new problems. As long as authors have little knowledge about accessible content design and/or motivation to ensure that their content is usable by everyone, the exponential production of inaccessible content means that individuals with disabilities will forever be left behind in information access and social and cultural opportunities. If everyone is a content creator (i.e., author), then everyone needs to know how to make information and products accessible for persons with disabilities and usable by all.

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