Universal Design for Learning Workshops for Engineering Faculty Professional Development

Executive Summary

For the MPLD645X Capstone project, I have created presentation materials and handouts for a series of four workshops, designed to inform faculty at the Milwaukee School of Engineering about neurodiversity in the college classroom and the application of Universal Design for Learning to STEM curriculum. The first workshop discusses common learning differences and other challenges faced by students, motivating an introduction to the idea of universal design, UDL, and possible applications. The remaining three workshops, respectively, cover the three core principles of Universal Design for Learning, with examples of applications in introductory engineering courses. As faculty at my institution have a large amount of direct contact with students, it is likely that faculty training in UDL will have a real impact on the student experience. Avenues for evaluation include pre/post training surveys using a variant of the ITSI or other faculty surveys targeting UDL practices, with the evaluation of impact on students as an eventual goal. The engineering education community is beginning to recognize neurodiversity and its educational challenges, and it is hoped that both the workshop materials and the resulting research results will motivate others in the community to implement UDL in their curricula.

Rationale for Project

My institution, the Milwaukee School of Engineering (MSOE), is a primarily undergraduate institution with the vast majority of students in engineering majors. Students with ASD and other learning differences are well-represented in postsecondary STEM majors (Wei, Yu, Shattuck, McCracken,

& Blackorby, 2013) and approximately ten percent of our student body is currently receiving services from our Accessibility Services office. Undoubtedly, we have many more students who learn differently but have not identified themselves as needing services. Faculty at MSOE have a large amount of contact hours with students, as our class sizes generally do not exceed 20 students, and we have no teaching assistants. Since faculty have nearly complete control over instruction, training that influences this instruction should have a direct and significant impact on the academic success and well-being of our neurodiverse student body.

The experience of researchers studying postsecondary STEM education for students with disabilities reveals some major challenges that can be expected when trying to effect change in services and curricula to support students who learn differently. A retrospective study of the 117 projects funded by NSF's Research in Disabilities Education program (RDE) from 2001-2011 found that across universities, faculty often lacked knowledge about disabilities and how to accommodate students (Thurston, Shuman, & Middendorf, 2017). In some cases, faculty held negative attitudes about the overall capabilities of students with learning disabilities, to the degree that some PIs reported their research was marginalized due to faculty assumptions about the students' academic potential.

However, many studies have found that faculty training has a positive impact on attitudes towards, knowledge about, and accommodations of learning differences (Murray, Wren, & Keys, 2008), (Lombardi & Murray, 2011), (Lombardi, Murray, & Dallas, 2013), (Dallas & Sprong, 2015). One study (Murray, Lombardi, Wren, & Keys, 2009) finds that faculty who participated in a disability focused *course or workshop* achieved statistically significant improvement in 8 of 10 student-supportive factors as compared to those who received no training, while faculty who reported "*other"* training differed significantly from the no-training group on only 4 of the 10 factors. This supports the choice of an in-person workshop as an effective delivery method for faculty training.

The aforementioned NSF RDE project study recommends several specific solutions to the challenges presented by negative faculty attitudes and lack of training. One recommendation is to "provide professional development and support in Universal Design for Learning (UDL)" (Thurston et al., 2017, p. 54). Research has been conducted in the application of UDL to postsecondary education; see (Seok, DaCosta, & Hodges, 2018) for a literature survey and (Schreffler, Vasquez III, Chini, & James, 2019) for applications to STEM courses in particular. Students have reported that they perceive that UDL practices and technology improve their access to material and their understanding of concepts, and contribute positively to their success (Kumar & Wideman, 2014). One study reports that the use of the online system MindTap for multiple means of representation, action, and expression had a significant positive impact on actual student performance (Dean, Lee-Post, & Hapke, 2017). Studies have shown that UDL training of instructors is associated with an increase in UDL-aligned practices as observed by students (Schelly, Davies, & Spooner, 2011), (Davies, Schelly, & Spooner, 2013).

UDL has a clear framework that should be understandable by STEM faculty who do not have training in universal design. I have created a number of examples of the application of UDL principles in introductory engineering courses to provide context for faculty. Furthermore, UDL has a wealth of online resources published by CAST and others that can be used to develop workshop materials with enough detail to allow participants to fully understand the theory and its possible application in engineering curriculum, including the UDL in Higher Ed website (CAST, 2019), online textbook (Meyer, Rose, & Gordon, 2014), and examples in (Rose, Harbour, Johnston, Daley, & Abarbanell, 2006).

Prior Work

Results of prior UDL training programs have been published, and some postsecondary UDL training materials are currently available to the public. Examples of prior training programs include the online Faculty and Administrator Modules in Higher Education (FAME) UDL training modules (Izzo, Center, Murray, & Novak, 2008) and SciTrain U, a series of workshops introducing faculty and staff to UDL practices (Moon, Utschig, Todd, & Bozzorg, 2011). These programs have demonstrated some success in improving faculty confidence in meeting the needs of students with disabilities, but these program materials are no longer available online. The website UDL Universe (California State University, 2019) provides materials for faculty workshops on universal design, including a high-level overview of UDL, a case study in biology, and rubrics for improving course syllabi. These materials, however, do not provide a detailed explanation of the UDL framework and are not adapted for engineering courses.

Within engineering education specifically, a number of papers have been published identifying the needs of students with disabilities in the engineering classroom and challenges for faculty, including (Mayat & Amosun, 2009), (Variawa & McCahan, 2010), (Ernst & Jr., 2014), (Pilotte & Bairaktarova, 2016), (Delp, 2017), and (Pearson Weatherton, Mayes, & Villanueva-Perez, 2017), but specific, implementable solutions are not included. A description of the application of UDL to introductory engineering courses will appear in an upcoming publication (Ross, in press).

The prior work that will be incorporated directly into the presentation materials includes the engineering curricular examples introduced in (Ross, in press), CAST's full text presentation of the UDL v2.0 guidelines (CAST, 2011) with associated graphic organizer, graphics from UDL-Universe's downloadable UDL 2-hour workshop presentation (California State University, 2019), and further content developed by my institution's accessibility services director. The works (CAST, 2011) and (California State University, 2019) are governed by the Creative Commons Attribution-Non-Commercial-ShareAlike 4.0 International License according to their respective websites, and will be shared per the requirements of the license. Participants will also be directed towards other online resources and publications available through our institutional library or online, including (Rose et al., 2006), (Colorado State University, 2012), (Meyer et al., 2014), and (Domings, Crevecoeur, & Ralabate, 2016).

Workshop Descriptions

The first workshop will be a 50-minute university seminar, intended to: 1) increase awareness of neurodiversity, 2) introduce the idea of universal design, 3) demonstrate examples of the application of UDL in introductory engineering courses, and 4) provide attendees with selected materials that will allow them to "dig deeper" into UDL and its possibilities in their classrooms. The first section of this workshop will be co-authored and co-presented with our accessibility services coordinator. She will remark on common learning differences present in our student body, and describe the idea of universal design using common examples in architecture. I will begin the presentation of UDL using brain scan imagery from (California State University, 2019) and relate the brain networks to the three UDL principles. I will provide *brief* illustrative examples listed in the Appendix (workshops to follow will examine their application more closely). Attendees will be specifically encouraged to read (Rose et al., 2006) for a full explanation of UDL and its application in a college course, sign up for the free UDL e-book (Meyer et al., 2014) and visit the ACCESS project website (Colorado State University, 2012) for more information on application of UDL and diagnoses commonly encountered among college students.

The workshops to follow will cover the 3 principles of UDL in more detail. As pre-reading, attendees will be asked to read the relevant section of (CAST, 2011). This online document has a detailed breakdown of the principles and guidelines, and suggestions for their application in educational settings. Material from this document, along with the engineering examples listed in the Appendix, will make up the bulk of the presentation materials for these remaining workshops.

The second workshop will focus on *multiple means of representation*, as many currently recognized best practices in engineering education correspond to this principle, allowing attendees to identify UDL practices they already use as well as new possibilities. A study found that multiple means of representation was the principle with the highest level of use among faculty *before* UDL training (LaRocco & Wilken, 2013), so starting with this principle may improve the attendees' feelings of self-efficacy in implementing what they may otherwise perceive to be "drastic" changes in their teaching. This workshop will begin with a discussion of the concept of cognitive load, as representations that are difficult for some students to access can place a great demand on cognitive processing. In my experience, the minimization of extraneous cognitive load is rarely considered in postsecondary STEM teaching, and improvements in this area via multiple means of representation can make a major difference in a student's academic success. For example, an action as simple as turning bullet points into check boxes in a lab activity can relieve students of the cognitive load of keeping their place and allow them to focus on the scientific principles illustrated in the activity.

One technique that will be introduced in this second workshop and re-emphasized later is the recording and posting of lectures. This is a controversial subject at my institution and some faculty have responded negatively when this accommodation was recommended for certain students. There is a published study on the use of lecture capture as a universal design principle (Watt et al., 2014) and the study indicates it was received very positively by students, with only 21% reporting that they had used it in lieu of attending lecture. This study will be specifically recommended as post-workshop reading. Recorded lectures greatly expand the means of representation by making information repeatable and captionable, with student control over time, tempo, and viewing environment. Best practices in the creation/adaptation of documents for accessibility will also be covered. My circuits laboratory assignments (see Appendix, item 4) will be used as an example.

The third workshop will focus on *multiple means of action and expression*. The guidelines pertaining to this principle are to provide options for physical action, expression and communication, and executive function. My personal experience indicates that most postsecondary STEM faculty do not consider means of action and expression outside of the traditional handwritten homework, typed reports, and the occasional oral presentation. Even within these categories, means of expression are constrained, e.g. a formal lab report to demonstrate understanding of a lab activity. While the development of certain physical actions and modes of expression are seen as specific educational goals related to workplace readiness, development of these very specific skills cannot be a primary goal of every assignment. In the third workshop, faculty will be asked to refine their educational objectives, and determine multiple means that students can use to express their competency.

The most common task STEM students are assigned is written homework, typically consisting of solutions to textbook problems in equation, narrative, or graphical form. Students with dysgraphia have great difficulty completing handwritten assignments, as well as taking handwritten notes. There are other physical options available for students to create scientific diagrams and type equations with lower demands on fine motor skill. This workshop will include a demonstration of the use of OneNote, combined with circuit diagramming software, to complete a typical introductory engineering assignment (see Appendix, item 6). Attendees will also be asked to brainstorm possibilities for alternate means of expression of technical competencies, such as video explanations, report alternatives such as user manuals or advertisements, and graphical illustrations.

Challenges in executive function are a common root cause of poor academic performance, especially in the first years of college. Since my institution has small class sizes with a large amount of faculty-student contact, we have the opportunity to provide coaching to help students develop their executive function capabilities. Academic coaching for executive function is a practice with demonstrated success, as seen in (Parker & Boutelle, 2009) and (Bellman, Burgstahler, & Hinke, 2015). This workshop will include an example intervention in the first term electrical engineering course which allows students to self-assess their executive function skills and receive guidance in their areas of greatest need (Appendix, item 2). The use of a master notebook (Appendix, item 5) and SMART goal worksheets supported by faculty led accountability measures (Appendix, item 8) will also be discussed.

The fourth workshop will address the UDL principle of *multiple means of engagement.* Certain aspects of this principle, such as the guideline to provide options for recruiting interest, will be familiar to STEM faculty as we try to place our activities in the context of interesting real-world problems. However, what may be “interesting” to the typical STEM faculty member may not apply to all students. The study *Changing the Conversation* (National Academy of Engineering, 2008) found that populations that were not regularly exposed to engineers or engineering, such as women and underrepresented minorities, responded more positively to messages that framed engineering as a career that helps people, rather than messages that emphasize scientific applications. In this workshop, attendees will be asked to develop a class example that involves human impact. Examples of embedded systems programming labs that have relatable impact will be presented (Appendix, item 1).

Students must be able to sustain their engagement and self-regulate when obstacles arise. One obstacle to engagement and self-assessment is a tutor or friend who provides answers and fixes problems. Assistance in the form of coaching can help a student to continue to engage with the material and understand where further efforts should be focused. Attendees will be provided with an example coaching guide for programming tutors (Appendix, item 7) which could be adapted to other disciplines. Promotion of a growth mindset will also be discussed in this workshop, and an example “tip sheet” for success in electric circuits, which reframes mistakes and weaknesses as opportunities, will be shared (Appendix, Item 3).

After the workshops, it is hoped that interested faculty will implement UDL in their courses, support each other in an ongoing working group, and share the results with the engineering education community at large. The Implementation Timeline section describes potential post-workshop opportunities.

Assessment Plan

Faculty attitude, knowledge, and practices regarding the teaching of neurodiverse students will be evaluated before and after the workshops. A pre-workshop evaluation will take place before the first workshop and a post-workshop evaluation after the final workshop, with the possibility of a post-workshop evaluation after the first workshop to evaluate the impact of a one-time overview workshop versus a detailed series of workshops. Survey instruments under consideration include the ITSI (Lombardi, Murray, & Gerdes, 2011) which evaluates faculty attitudes and actions related to inclusive instruction and campus support, and the instrument used in (LaRocco & Wilken, 2013) which measures stages of concern and levels of use of the 9 design guidelines within the UDL framework.

Studies have measured the impact of UDL practices on students' perceived experiences, using instruments such as the ITSI-S (Gawronski, Kuk, & Lombardi, 2016), a survey of UDL classroom practices in (Schelly et al., 2011) and semi-structured interviews in (Kumar & Wideman, 2014). Evaluation of student impact is a longer-term goal of this project, to be undertaken after faculty at my institution have developed and deployed UDL practices in their classrooms.

Implementation Timeline

My institution is supporting the development of this workshop as it has funded the tuition for the capstone course and has committed to granting a university-wide seminar period for the first workshop. The timing of the first workshop will primarily depend on the amount of time it will take to choose our pre/post workshop evaluation instruments and obtain IRB approval. Given typical lead times, it is likely that the first workshop would take place near the end of our winter quarter (January/February 2020) and the following three workshops would take place in our spring quarter (March through May 2020) at times arranged based on interested faculty. This would create an appropriate timeline for publication at the American Society for Engineering Education (ASEE) 2021 annual conference with the possibility of a pre-conference UDL workshop presentation for the engineering education community at large. Based on the success of the workshops, participating faculty at my institution may design evaluations of student impact over the summer of 2020. Presentations at other conferences focused on neurodiversity or special populations in STEM are also possible.

Impact on Students, Institution, and Community

My institution occupies a unique position in the educational marketplace, as a school offering ABET accredited engineering bachelor's degrees, but in an environment of small class sizes, continuous faculty-student contact, and a supportive goal-oriented environment, rather than the "sink-or-swim" stereotype sometimes associated with STEM. Universal Design for Learning provides roads for students with all types of differences resulting from biology or life experience to reach their professional and personal goals. My institution is in a position to implement the UDL interventions described in this report, as well as a spectrum of other ideas contributed by the faculty and students who will create curriculum together.

I expect that if UDL is widely implemented at my institution, student retention will rise and we may be able to attract an even more diverse student body with our demonstrated success. I believe that professors who design curriculum using UDL will create a culture that inspires students to design *engineering solutions* that take into account the diversity of potential *users*, creating multiple modes of interaction with products, and considering multiple motivations for users to engage with a product. If we support a truly diverse population to leverage their unique talents and become engineers, all of us will benefit from the useful products and technology that will result. If the workshops inspire faculty at other institutions to practice UDL, a broader culture change could potentially occur. I believe students and their parents are carefully considering institutional culture as they make their college decisions, and this could put pressure on institutions to consider practices like UDL.

Culture change is a long-term goal, but I am fortunate enough to be in a position to introduce UDL to faculty at my institution and others. Faculty who possess both the teacher's instinct towards supporting students and the engineer's instinct towards creative design could do great things with UDL and I am excited to see the future impact of this project.

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Appendix: UDL Engineering Examples

These examples are my creations and are described in (Ross, in press). All documents are available upon request. The "multiple means" presented by each intervention are listed after the description. These examples are used in the previously described workshops.

1. The author coordinates her institution's first-year experience in the EE major, which spans the discipline from applied engineering mathematics to circuits to embedded systems programming. Hands-on labs are integrated into all courses and are often inspired by products that help people. Examples include a Fitbit, a heart patient simulator, and a light sensor with audio output for the visually impaired. [*recruiting interest, sustaining effort and persistence, comprehension*]
2. The first term EE course begins with a self-assessment of executive function to identify areas of challenge and strategies for growth. Using Brown's model of executive function (Brown, 2008), coaching strategies developed by Landmark College (Hecker, n.d.)are provided for areas of challenge that students identify, such as activation for students with ADHD, and emotion/action for students with autism spectrum disorder. [*sustaining effort and persistence, self-regulation, executive function*]
3. A success strategies document was developed for electric circuits, which emphasizes a growth mindset for circuits skills. It provides concrete study strategies and thought processes to help students fight stereotype threat, self-assess accurately, and recover from setbacks. [*sustaining effort and persistence, self-regulation*]

4. Circuits laboratory assignments were revised to conform with best practices for accessibility, and include scaffolding to minimize working memory used on “bookkeeping” and maximize retention of “big ideas”. [*perception, comprehension*]
5. Scaffolding was developed for the creation of a “master notebook” integrating all aspects of a circuits course (schedule, grade tracking, class notes, homework, labs, exam prep) and all media (written class notes, recorded lectures) so that students may access and organize material according to their own needs. [*perception, language and symbols, comprehension, executive function*]
6. A video walkthrough of the use of software to efficiently complete circuits homework was created to help students with dysgraphia/weak fine motor skills. Handwritten equation recognition in Nebo and OneNote are demonstrated along with keyboard entry of TeX equations in OneNote. [*physical action, expression and communication*]
7. A coaching document was developed for digital logic and embedded systems tutors, providing them with strategies that will help them help students to develop independent problem solving, self-assess, and improve generalization/transfer of knowledge. [*sustaining effort and persistence, self-regulation, comprehension, executive function*]
8. Sample SMART goal worksheets were developed to support the strengthening of executive function skills as they pertain to success in circuits and embedded systems programming courses. [*sustaining effort and persistence, self-regulation, executive function*]