

## Applied Universal Design for Learning In STEM Education

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### ABSTRACT

Universal Design for Learning (UDL) is a field of inquiry and practice that proactively designs course content in a manner that is accessible to as wide of an audience as possible. The approach is one where the instructor pre-emptively addresses course content that targets defined and/or undefined accessibility issues. In this way the benefits of improved accessibility are available to the entire class rather than just those seeking accommodation. Utilizing a mini-case study format this paper examines the process involved in implementing UDL practices in a cohort of STEM courses, the perceived accessibility challenges that were targeted by each intervention, and how the design in each class allowed for the gathering of evidence about the use and/or effectiveness of the target materials. Collectively these case studies reveal a glimpse into the diversity of thinking and approaches that were utilized under the premise of improving accessibility of course content. It takes an approach of continuous improvement through evidence-based practices by demonstrating the implementation process for gathering evidence about UDL practices to allow for continual improvement in STEM education.

Keywords: STEM, Conference Proceedings, Best Practices, Teaching Quality

### INTRODUCTION

Universal Design is often defined as a concept whose roots are grounded in three areas, design of physical environments (residential and commercial space), web development, and most recently, the field of teaching and learning (Universal Design for Learning, UDL). Its intent is to create barrier-free environments that enable today's teachers to apply universal design concepts in ways that support the needs of the widest range of learner differences. With the learning needs of today's student population becoming increasingly diverse, an enhanced understanding and application of UDL is essential. UDL is a field of inquiry and practice that considers ways of developing course content in a manner that is proactively accessible to as wide of an audience as possible.

To better understand the idea of universal design it is helpful to have examples that illustrate the principles involved.

*A good example of universal design in action comes from the history of television captioning. When captioning first became available, it was an expensive add-on purchase intended for people with hearing impairments. Building captioning into every television, rather than retrofitting it later, turned out to be a better, and more universal design. It 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 (Rose & Gravel, 2010, p.119).*

Similarly the design of entrances to restrooms in airports and other public buildings that have evolved into door-less structures is an example of universal design. Originally designed to accommodate the needs of individuals with mobility challenges, they also benefit individuals hauling luggage and reduce the number of surfaces travelers touch, reducing the opportunities to spread pathogens.

While UDL isn't as mature as other areas of Universal Design, it has at its basis the same general premise; the idea that by designing in a way that is more accessible to a target group you are also likely increasing the accessibility for others. One of the challenges for UDL is that innovations that are introduced to improve accessibility for one group may actually impede accessibility for another group. The introduction of video based instruction may help some students, but create barriers related to visual or hearing difficulties for some and technological issues for others.

It is within this environment, with course content and interaction becoming more and more technology based, that the study of UDL has emerged. There are three (3) guiding principles that underpin UDL:

- Principle I: Provide multiple means of representation
- Principle II: Provide multiple means of action and expression
- Principle III: Provide multiple means of engagement (The Three Principles, 2011)

The principles of UDL as they are well documented and go well beyond the scope of this paper. This paper presents a series of mini-case studies to illustrate a variety of approaches taken to introduce UDL into the STEM curriculum as part of a broader consortium of instructors who are implementing these principles into classes at the University of Wisconsin-Stout.

This research takes a Participative Action Research (PAR) approach (Kemmis & McTaggart, 2000) to addressing perceived problems related to instruction in Science Technology Engineering and Mathematics (STEM) courses. "PAR is neither a methodology nor an epistemology as such. Rather, it is an exploration into praxis that simultaneously explores problem solving interests and research interests" (Tharp, 2005, p.143). PAR recognizes "the active and deliberative self-involvement of the researcher in the context of his/her investigation" (McKay & Marshall, 2001), and as such is an appropriate framework from which to approach evidence based efforts to research and improve accessibility of course content. PAR investigation processes include the steps of Plan, Act, Observe and Reflect in dual cycles of action and research that are parallel and have affects upon each other. This closely parallels the instructional cycle of planning instruction, delivering instruction, and assessing learning outcomes (Scott & McGuire, 2008) but formalizes the research component in the effort to contribute to the evidence based practices associated with UDL.

For those who understand UDL, they can appreciate how overwhelming it could be for faculty to create a course, never mind a program or an entire STEM college of courses that could effectively incorporate UDL principles. While it is challenging, the metaphor of the starfish story might be a common response heard from those who are passionate about UDL and its application. The unlikely hero find him or herself on a beach covered with starfish that the tide had stranded. The hero starts to toss the starfish back into the ocean one by one. A stranger sees and tells the hero that there are way too many starfish on the beach for the hero to make a difference. The hero picks up another starfish, tosses it into the ocean and replies, "I made a difference to that one". This could well describe the situation facing academia regarding UDL.

This paper looks at three mini case studies to illustrate how instructors in a diverse set of STEM courses started from where they were at and began the process of addressing accessibility issues related to their courses based upon the principles of UDL. At the time of the writing of this paper, the first cycle has not yet completed. As such, it does not focus on the results, but instead focuses on the process each instructor took in designing and implementing UDL interventions within their own classes and the methods for gathering evidence about the results of those actions.

### **BACKGROUND**

At the University of Wisconsin-Stout, a mid-sized Midwestern university, ten faculty members explored what Universal Design for Learning (UDL) could and should look like within their specific courses and disciplines. These instructors participated in a year-long, multi-phase research project designed to infuse Universal Design concepts throughout their curriculum. Their disciplines included Communications Technology, Construction, Business, Operations and Management, Chemistry, Biology, and Education.

A call for applications was issued in the spring of 2011, with eleven of them being received in April 2011. The applicants were selected based on their responses to the following questions:

1. Are you able to commit to being actively involved with this project from August 2011 until May 2012?
2. Do you teach at least one course per fall and spring semesters and are you scheduled to teach a course during spring 2012?
3. Have you previously taught an on-line course or are you planning to teach one during 2011-2012? If so, did you convert a face-to-face course to an on-line offering? Please describe your experience in creating and disseminating your on-line course and what you learned from the experience.

All eleven applications were approved, with one participant later dropping out of the study. Once selected for the program, participants were asked to read the book, *Universal Design in Higher Education: From Principles to Practice* (Burgstahler & Cory, 2008) as a pre-requisite to attending a two-day Universal Design Summer Institute workshop in August 2011. The workshop facilitator was the nationally recognized expert in Universal Design, Dr. Dave Edyburn from UW-Milwaukee.

During the workshop, faculty members dialogued about a variety of topics including factors that are impacting today's teaching environment, an introduction to UDL both from a historical as well as conceptual based understanding, the dissecting of course content for the purpose of meaningfully infusing UDL principles, examples of UDL classroom applications, and how to assess the effectiveness of UDL course assignments. The conversations were thought-provoking and energizing as faculty grappled with what could best be summarized as a new way of thinking about teaching and presenting content to students. Many of the participants struggled with such questions as:

1. How does the application of UDL principles significantly differ from "just good teaching" in the classroom and across the curriculum? How could specific assignment design be utilized to enhance accessibility and improve student learning?
2. What would different UDL based course assignments look like coming from diverse disciplines?
3. How can UDL be applied and assessed in ways that positively impact student learning and enhance the quality of the teaching environment for both students and faculty?

As part of the program requirements, faculty members began meeting twice a month during fall to discuss, plan and develop UDL teaching and learning activities that they would then implement and assess in their spring semester 2012 courses. Each faculty member was committed to selecting at least one course that they would insert one or several UDL oriented assignments/projects into. Individual faculty agreed to facilitate the monthly meetings. Although Dr. Edyburn did not participate in these regularly scheduled meetings, he did creatively interact with the participants during December 2011 through online teleconferencing. A wealth of ideas flowed from this synchronized conversation including the realization that a definition of UDL as it pertained to teaching in the classroom was lacking. As a result, participants suggested that it be defined as the intentional effort to

improve one's course or assignment design in an effort to make learning more effective and accessible to those who have a learning challenge while at the same time making it more accessible to everyone. They further agreed that instructors who want to practice effective UDL need to incorporate multiple means of representation, multiple means of expression, and multiple means of student engagement. In addition, faculty members felt that it was essential that effective universal design applications be based on a deep understanding of who one's students are before attempting to infuse UDL concepts into the classroom. They discussed the need to identify who teachers want to reach, which particular students are being targeted, and what are the most descriptive student characteristics, including physical, mental and emotional abilities. They acknowledged the challenge of gathering this information since most faculty members develop their assignments and course strategies prior to actually meeting their students on the first day of class. However, an understanding of previously collected university data, conversations with a sampling of students enrolled in an upcoming course, and dialogue with colleagues, particularly those involved in disabilities services, could help to create a meaningful, beneficial student profile.

In addition, the synchronized conversation emphasized that in order for the implementation of UDL to be effective, course tools and assignments had to be developed that encourage and produce student engagement, and that students needed different options and techniques for accessing information. In other words, diversity and accessibility are prerequisites for student engagement. Faculty agreed that an ongoing challenge exists regarding how to offer students different options (choice) for demonstrating their comprehension of course content while still creating meaningful challenge (academic rigor) in the course.

Finally, participants were asked how they planned to connect student learning outcomes to their UDL efforts. Numerous suggestions were made including:

1. Look at which students are using which course tools by using the university's course management software (CMS), or other techniques.
2. Examine the CMS grading tool to track student progress.
3. Identify ways to make course content more accessible to students with learning challenges.
4. Make sure that the use of pre & post surveys is directly tied to a specific course assignment/unit/concept, etc.
5. Use CMS to identify which students are using text content versions and which are watching video or both.
6. Compare students reading of text and watching a visual/audio version using screen capture software. Ask students which they found to be most easily accessible. Explore various text and text-to-speech options for assignments.
7. Gave examples of different tools that could be used including lecture capture software, CMS for making check lists to help students stay on track with assignments, an assignment calculator, etc.

With the start of the spring semester, Universal Design project participants finalized plans for implementing assignments and/or larger projects that they intended to infuse into their course(s). During this semester, the project received additional funding to launch a comprehensive pre-and-post survey. With assistance from the campus Applied Research Center, the questionnaires were electronically distributed. The pre-survey consisted of 15 questions that assessed students' perceptions of how effectively previous instructors accommodated their sensory, learning and communication needs in previous courses as well as collected basic demographic data. A post-survey comprised of ten questions was administered to the same students to assess how well faculty participants in the current Universal Design research project satisfactorily met their educational needs and how

accessible the course was to the broadest range of students. Participants' attitudes regarding their learning environments were measured using a Likert-scale. One open-ended question was included in each of the surveys in order to allow respondents to voice additional comments. Survey findings will be analyzed using descriptive statistics, a T-test and Chi-square analysis; however findings were not available at the time of this writing.

The following discussions showcase examples of what several of the project's participants specifically did in their spring semester courses.

## **CASE STUDY I**

### **Setting**

This case study is on providing additional content in the form of tutorial materials to the learners in a Structural Systems class for seniors in a four-year construction program at the University of Wisconsin-Stout. The class was delivered in a traditional classroom setting.

### **Problem Statement**

The study and documentation of learning styles is well researched and documented. Generally speaking, learners can be classified as visual, auditory, or kinetic learners. In summary, visual learners learn best by watching, auditory learners learn best by listening, and kinesthetic learn best by doing. In the ideal classroom, educators will present the material using varying methods that will cover all three learning styles. In traditional lecture only classrooms, visual and auditory learners may reach their learning potential while the kinesthetic learners are less likely to be engaged. Universal Design practices encourage using methods that may be targeted to directly benefit some learners but have the potential to benefit all learners. With these ideas in mind, tutorial materials in the form of both text and video were produced and made available to the students to improve learning.

### **Implementation**

The tutorial materials were provided to the students in the university's course management system (CMS). The additional content was intended to be tutorial materials. As tutorial materials, no new concepts were covered, viewing the materials was not required and the exams were designed such that the learner should be successful in the class if they attended lecture and completed the required homework.

In this class, students are taught to solve problems such as designing a steel beam. The problems are applied math problems that require about five steps to complete. Screen capture videos of example problems were produced using a tablet computer and Camtasia software. In the videos, the problem was presented and the solution was explained step-by-step with an audio explanation of the steps by the instructor. The videos were limited to about 3 minutes long. Previous research has found that learners prefer short videos less than 3 minute (Gawlik, 2009). The videos were produced in MP4 format and saved in the content section of the CMS for the class and the students could view the tutorial videos on-line. In addition to a video solution of the problems, a text version of the example problem solution was also available. The text version is a screen shot of the same problem that was recorded on the video. With both the video and text versions of the problem available, the student has the choice of which versions to select.

### **Assessment / Reflection**

The CMS is capable of compiling data regarding content use. The data collected included the name of the student, number of times they visited the content and the duration. The students were informed that the use on the content did not impact their grade and was on optional activity. After an exam was completed, the amount of tutorial use was compared to

the exam scores. Additional data was also gathered including the student's cumulative grade point average. It is intended that a qualitative study will be done with target students at a later date. The purpose of the qualitative study is to further investigate which students benefited the most with the tutorials available.

The goal of any tutorial project is to increase learning. By comparing exam scores to tutorial use, conclusions can be made on which students may have increased their learning the most by using the tutorial materials. Additionally, the qualitative study will help identify future students that may also benefit and also determine if modification to the tutorial materials are appropriate.

For continuous improvement, the data from this research will be analyzed to:

1. Determine if video improves overall learning for the class
2. Determine if the effort to make the tutorials is worthwhile
3. Determine which students can benefit most from tutorials and make sure that they are promoted to the targeted students.

In this way it will feed back into the practice cycle allowing for the continuation of the PAR method aimed at continuous improvement in the course materials for this class.

## **CASE STUDY II**

### **Setting**

The Built Environment is a 100-level general education, technology category course delivered in a traditional classroom setting. The student population can be a student in any major, and there are no pre-requisites to this course. The course is an interdisciplinary study of the built environment, including physical resources and the evolution of human behaviors which inform its design. The course topics include construction and its relationship to resources, materials, and the culture in which it takes place.

Upon completion of the course, students are able to describe the relationship between examined built structures and the resources/technology available to the society that produced them; describe the relationship between certain built structures and the needs of the society, which produced them; identify contemporary advances regarding built environment regulations; identify ethical issues related to the consumption of resources in the built environment; and identify practices that encourage individual, professional, and civic responsibility regarding resource consumption in the built environment.

### **Problem Statement**

In this case, the focus was not on a specific identified problem. Rather, it was a broad approach to applying UDL principles and educating students about UDL through application to the course content in general.

### **Implementation**

The instructor prioritized flexibility in the ways the information was presented, how students could engage, and how students could respond to demonstrate knowledge and skills, while maintaining consistent high achievement expectations for all students. To assist in further explaining the UDL concept, students were provided online UDL links and asked to research its importance, as a course assignment.

To address UDL Principle I: To provide multiple means of representation to give learners various ways of acquiring information and knowledge (Rose & Meyer, 2002), course lectures notes and presentations were posted on the CMS with online links to all references. Assignment descriptions and deadlines were explained verbally in-class, as well as posted on the CMS. Detailed grading rubrics were provided for each assignment explaining how assignment points were earned and suggested areas of improvement. Multiple opportunities

for assignment feedback, from the instructor and/or peers, prior to final submittals were provided. Outside-of-class office hours were held weekly to meet with students, including flexibility of date/time that could be arranged with instructor.

To address UDL Principle II: To provide multiple means of representation to give learners various ways of acquiring information and knowledge (Rose & Meyer, 2002), course content was delivered through a combination of online readings, Power Point slides, guest presentations, YouTube videos, and instructor lectures. Course format highly prioritized engagement through in-class dialogue, online discussion boards, and reflection exercises demanding critical-thinking. The course promoted collaborative group learning through team assignments.

To address UDL Principle III: To allow multiple means of expression to provide learners alternatives for demonstrating what they know (Rose & Meyer, 2002), student assignments allowed choice of topic to be researched as well as the format of the submittal.

### Assessment / Reflection

To gather evidence about the effectiveness of the targeted UDL strategies, pre-and post-course surveys collected student feedback regarding their perceived access to learning in The Built Environment, compared to other courses at the University of Wisconsin-Stout. An end-of-term open-ended reflection question was conducted online, that listed all of the UDL strategies used in the course and asked for the student's reflection of each. To assess increase in learning, this qualitative information will be reviewed and compared to academic performance in other courses (GPA) compared to performance in this course.

The students in this study underwent a qualitative reflection process that asked them to "share one or two specific examples of course activities that best promoted your access to learning". Figure 1 shows the responses to that question, Highest ranking were providing choice, discussion format, posting all information and providing rubrics. Based on the reflection from the students the instructor intends to continue using the UDL strategies used in this investigation.

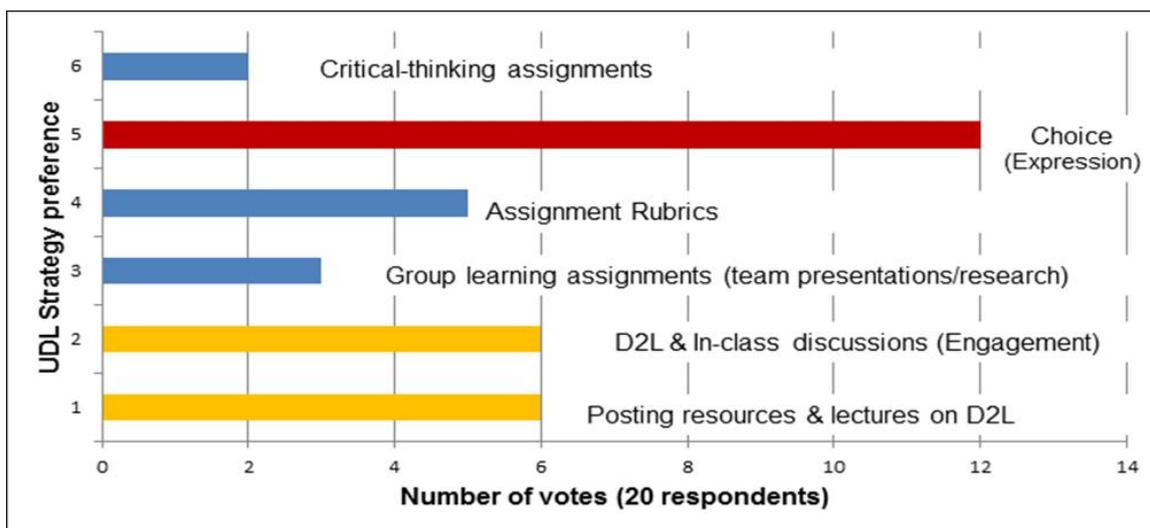


Figure 1: UDL Strategy Preferences

## CASE STUDY III

### Setting

This case study took place in a Web Design and Distribution Course. It was implemented in two sections of the course, one of which was purely online and the other was a face-to-face / online hybrid.

### Problem Statement

In the fall of 2011 the researcher introduced a new textbook and subsequently a major overhaul of an established web design course. This course is offered in hybrid and online only formats. As such, all content must be made available through a mediated environment. Often the course materials are made available through e-learning modules relying heavily on screen capture video as the delivery medium. The first semester the revised course was offered the new materials was in fall 2011 and was delivered in a hybrid format.

This provided the benefit of direct interaction at the instructor-student and student-student level. Discussions between students in the presence of the instructor provided a glimpse into challenges of the current format when students discussing the videos were split in their assessment of the video instruction ranging from “loving” the videos to “hating” them. Prompting by the instructor led to comments from some students who liked the videos because they could pause them and/or return to content and from students who did not like them because they had difficulty following the videos in general, or applying the skills while the videos were playing.

This discussion revealed that there is a deficiency in addressing the learning needs of students who are challenged by using video as a learning format. Addressing this deficiency was the area of focus for the UDL intervention in this case study.

### Intervention

This study involved the use of a Universal Design Intervention in materials designed to support learners in the effort to transition from theoretical concepts to applied skills. The educational tool utilized to support the transition from knowledge to applied skills is an applied case study that students build upon from week to week. Each week introduces a different set of learning objectives representing specific skills necessary to understand the fundamentals of web design. Because the case study builds from week to week the artifact that results from each week’s activity must be completed correctly before they can proceed with the next exercise.

Preliminary exposure to the necessary knowledge is accomplished through reading the textbook chapter related to that week’s module. The design intervention consisted of providing a choice for students to utilize audio/visual, text and/or hybrid materials explaining the case study. Each weekly assignment provides the opportunity for assessing if the student has applied the requisite skills and achieving the learning goals for the module. Materials for three (3) of the case study modules were created in three formats. The first format was text based and in some cases contained images to illustrate desired results. The second format was hybrid in that it contained text directions, but was supported by a number of visual cues to help move the student through the interface to develop the content. The third consisted of screen capture video showing the instructor walking through the directions. For all three types of materials care was taken not to give exact step-by-step directions, but rather provided goals and left the interpretation and achievement of those goals up to the student. In this way achieving the assignment goals indicated a mastery of the concept or technique that was being taught.

### **Assessment / Reflection**

Students were asked to complete a 10 question survey tool providing for assessment of learning styles as visual, auditory or kinesthetic.

The assessment of accomplishing learning objectives in all cases was based on the accurate and complete creation of the required web artifact. Assessment was on a pass/fail basis and the solution was provided after the required completion date and prior to beginning the next case study exercise so the students could compare and update their work to the solution. This process is necessary so they can proceed even in those instances where they have not successfully applied the skills from a given module. This process also isolates each week's activities and skills demonstration from prior and subsequent modules allowing for micro examination of resources utilized and skills mastery in each module.

At the time of this writing the data collection has not been completed, but it will consider the following:

1. Is there is a correlation between the learner's self-perception of their own preferred learning style and their choice of instructional materials.
2. Is there a correlation between the learner's choice of learning materials and their ability to demonstrate mastery of that week's learning objectives?

Preliminary data analysis shows that many of the students are using more than one of the instructional resources provided as part of UDL's multiple means of instruction. The ability to mix and match between the video, text and hybrid resources is well received by the students as seen in this quote provided by one of the students in a formative survey given after one of the assignments:

*"I always prefer video instruction, and believe it is very helpful for understanding the material. I also like that I can learn a lot of material very quickly compared with reading. The ability to pause and re-watch parts is also helpful. When completing the assignment, it is nice to have a text document as a companion to the video. The student can review the material in the text document without having to find the part of the video that pertains to that topic. Most of the time I learn more easily from the video, but like to have the text document as an organized reminder of the details in the material."*

As a result of this investigation, the instructor will continue utilizing UDL strategies in the course. Additionally, it became clear that existing assessment provided details about completion, but did not provide adequate assessment of learning. As part of the continuous improvement process, the assessment will be revised to more adequately assess learning. In this process, the PAR process will move into the second cycle as the research informs the instruction and thus begins the second teaching/research cycle.

## **CASE STUDY IV**

### **Setting**

This case study is on the use of the Virtual Modeling Technique taught in an operations and management course. Virtual Modeling is a technique employed to help students better understand operation processes.

### **Problem Statement**

Students without industrial experiences often have difficulties understanding operation processes. This often results in misunderstanding operation management, lean supply chain management, and quality assurance courses. Creative approaches are needed to enhance students' awareness of the operation systems that will improve their learning outcome,

encourage their use of critical thinking, and strengthen their ability to identify and solve problems.

Virtual Modeling, which uses simulation packages virtually illustrates operation systems, and gives students an opportunity to actually see the dynamic industrial operations.

### **Intervention**

This project brought the concept of virtual modeling, the lean manufacture implementation technology, to instructional pedagogy that helps the industries better understanding their process and eventually achieve lean operations. By watching these dynamic virtual processes, students will easily learn how to measure and analyze the processes. In addition, they are also asked to provide an improvement method to improve the processes' efficiencies. This new instructional teaching technology will enhance students' involvement and critical thinking.

The models were used in the following steps through the semester,

1. At the beginning of the semester students were asked to form a team on a process improvement project.
2. Based on their academic background, the students can choose their project from different types of operations such as manufacturing, service or supply chain.
3. A virtual modeling process with several problems to be solved is then distributed to each team.
4. Students apply the methods and theories learned from class to measure and analyze the process, determine the improvement opportunities and propose solutions.

### **Assessment / Reflection**

The solutions were put into virtual models again by changing the simulation parameters and run in class. Students are able "see" if their solution works. By doing this, students can evaluate their own work.

Complicated models were then given to class so they could practice the theory again.

## **CONCLUSIONS**

Using a Participative Action Research approach to studying UDL researchers can formalize the process of continuous improvement in STEM courses by combining research components with established procedures for universal instructional design. While the goals of UDL are similar to and overlap the Scholarship of Teaching and Learning (SOTL), there is debate over whether UDL is "just good teaching". As a result of the emergence of the authors in this project, one of the conclusions is that UDL is compatible with and perhaps a subset of SOTL. However, it is distinguished from SOTL in that there is a planned and systematic approach in UDL to identify ways in which learning can be improved by interventions addressed at overcoming potential barriers to learning which are designed into some course content.

This paper used four (4) mini case studies to illustrate how STEM instructors initiated the process of introducing UDL into existing classes and included methods for gathering evidence about the effectiveness of these approaches. As part of the PAR process, the research findings will inform the course design as the researchers intentionally design curriculum improvements based upon reflections of the findings. This paper shows a variety of ways that can be used to go from the principles to the applied practice of UDL and the flexibility of research design that can be utilized to examine continuous improvement practices in STEM classes.

The STEM instructors involved in this paper have found that it can be challenging to design course content utilizing UDL principles. However they also found that many students

take advantage of the opportunities and choice provided by those design decisions to find the mix of materials that best suit their own personal learning needs. In this way instructors are actively working to mitigate learning barriers which they may not have been aware of prior to participating in a UDL study.

Although the ten original applicants from the broader UDL cohort at the University of Wisconsin-Stout are in the throes of completing their yearlong program commitments, plans are actively underway for identifying a new cohort to further extend the infusion of UDL into more University of Wisconsin-Stout classrooms. In addition, an invitation was extended to the current faculty to participate in another more advanced yearlong project, of which four individuals have committed to continuing on with their UDL research.

The project participants, with their diverse background of disciplines and different approaches to teaching, have made valuable inroads into moving beyond the traditional disabilities model of simply accommodating students who self-proclaim a learning challenge that limits their ability to access course materials to becoming instructors who preemptively present course content in ways that address and account for defined and/or undefined accessibility challenges. In this way, they are making the benefits of improved accessibility available to the entire class rather than to just those seeking accommodation.

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