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An Evaluation Using Universal Design for Learning

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Introduction

Education is constantly evolving, improving, and adapting to accommodate all students. The key word in my opening statement is “all”. The National Council of Teachers of Mathematics (NCTM) is one organization striving to make improvements to the field of mathematics education. Their mission statement is “NCTM is the public voice of mathematics education, supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development, and research” (NCTM, 2023).

For my honors project, I chose to conduct research on the level of inclusion and educational equity being produced by this widely accepted organization, in order to either commend this source on inclusive teaching practices or challenge it to produce more inclusive resources for mathematics education.

I decided that I wanted to investigate work published by the NCTM because they are a professional organization that is well-established and aims to improve mathematics education. Which, I believe, is a strong reason to investigate the inclusivity of their lessons. An article published by the NCTM states, “universal design for learning is a process that maximizes learning for all students, minimizes the need for individual accommodations, and eventually benefits every learner by considering different ways that students’ minds are activate” (Hunt & Andreasen, 2011, p. 168). Since the NCTM is so popular, it is important to make sure that their claim on inclusion is being met and demonstrated for their members. Evaluation, whether the outcome is positive or negative, is significant to ensure that the organization is effectively promoting accessible content and is not complacent.

I originally wanted to focus my research on adaptations in mathematics education for students with disabilities. However, because my degree will place me primarily in general
education, I shifted my approach by considering the universal design for learning pedagogy instead. This shift will be beneficial for my future career because this pedagogy is highly applicable in today’s education system. The goal of the Universal Design for Learning is that lessons are made accessible preemptively to benefit all students rather than for individual students as the lesson is being taught; “The fundamental premise behind UDL is that lessons can be planned in ways that readily adapt to the variability among students, instead of expecting students to adapt to—or teachers to retrofit—lessons to meet students’ needs” (Bostic et al., 2021). Which is effective because “by focusing on access, we [educators] shift our gaze from identifying the ‘problem’ within the student to identifying the issues of access in the instruction or mathematics itself” (Lewis, 2018). In other words, this approach takes individual adjustments to lesson planning for students out of the equation and is intended to make learning and teaching more effective for the students and the educator, by weaving accessibility into the entire lesson.

Figure 1: *Note:* This graphic comes from CAST, a non-profit organization for education research and development (CAST, 2018).
To provide a general explanation of UDL, it reduces the necessity for accommodations for individual students, supports maximal learning for all students, and benefits all students as UDL considers the multiple ways that students may best learn content (Hunt & Andreasen, 2011, p. 168). Within the UDL approach there are three main components (see Figure 1). The first component is the most broad, it is the heading that each guideline and checkpoint falls under. There are three principles: showing multiple means of engagement, representation, and action and expression (CAST, 2018). Then, beneath each principle, there are three guidelines (i.e., nine guidelines total) for which a checkpoint can be categorized into. Then, most specifically, there are thirty-one checkpoints which describe a certain occurrence of UDL. To provide an example: if during a lesson on circumference a teacher allowed their students to choose an object to bring in to measure, the teacher would be exemplifying the UDL checkpoint of “individual choice and autonomy” (7.1), the guideline of “provide options for recruiting interest” (7) and therefore the principle of provide multiple means of engagement.

The intention behind UDL’s creation and current implementation is inclusivity for all students and all types of learners. UDL is seen as an opportunity to increase accessibility of curriculum for students by reducing barriers to learning that play a role in educational inequity. I have studied UDL in several of my education courses at Bowling Green State University and have found it to be very prevalent in mathematics education. A familiar mathematics education organization, the NCTM, published an article that explained that every student, within any range of ability can engage in rich mathematics, and the Universal Design for Learning provides support to meet the needs for all individuals within a classroom of diversity (Brown et al., 2022).

The research question that I am proposing is: Do the “Activities with Rigor and Coherence”, published by the NCTM demonstrate universal design for learning principles and
guidelines? Then, beyond this general question, I will investigate which UDL elements appear most frequently within the ARC’s as well as whether there is a correlation between UDL elements and mathematics education standards. With this research I am hoping to push major professional organizations in mathematics education to produce inclusive resources for education and to specifically benefit the NCTM in their goal to improve mathematics education for all students.

**Review of Literature**

The NCTM has published a set of lesson plans called “Activities with Rigor and Coherence” (abbreviated as ARCs) in attempt to “scaffold effective teaching and support enactment of the eight Mathematics Teaching Practices articulated in Principles to Actions as well as the instructional guidance set forth in 5 Practices for Orchestrating Productive Mathematics Discussions” (NCTM). The ARC’s are an effective focus for this research because they were published to demonstrate lessons that are effective and support the math education practice standards. Evaluating the implementation of UDL within these lessons will shed light onto the accessibility of this national organization's mathematics lessons along with their claim of being lessons that effectively execute educational standards.

To provide information on the Universal Design for Learning, and its relevance, it was created in 1984 by two researchers from the Harvard School of Graduate Education. The Every Student Succeeds Act stated, in 2015, that Universal Design for Learning (UDL) is a scientifically valid framework, based on evidence, that fosters access to instruction for all children (Every Student Succeeds Act, 2015). A non profit organization for education research and development called CAST created the UDL guidelines and framework that are commonly utilized today.
Evidence that supports the implementation of UDL in the classroom suggests that the UDL framework supports instruction that has reduced barriers for students with a range of diverse learning needs, these include students with disabilities, English language learners, and those with diverse socioeconomic and cultural backgrounds (Young-Smith, 2022). UDL can serve as a tool to address the needs of all students because where educators may be insufficient in their effort to create equity among the diversity of learners, UDL demonstrates effectiveness to “proactively address the variability of learners so that all children are meaningfully engaged in the learning process” (Young-Smith, 2022).

However, it is not limited to supporting these students, the underlying idea that is fundamental to UDL as a concept is that by lesson planning effectively can address learning diversity in the classroom by remedying the barriers that are inherent within a curriculum (Israel et al., 2014). So, ultimately UDL promotes flexibility to access and content appropriate for the strengths of the student rather than insisting they adapt to the teacher's lesson.

To further understand the UDL framework and its components, for the purposes of the results of this research, I will expand on each UDL heading. The first heading is the principle of Engagement which references the impact of the students’ own motivation. The second is to provide multiple means of Representation which refers to the instruction that fosters the communication of information for students – learners’ variability in comprehending information entails that there is no single method of representation which optimal for all, therefore, lessons should incorporate multiple representations of information in order to reach all learners (CAST, 2018). The third principle refers to students’ options for action and expression which focuses on the strategies that students use to communicate what they learn, therefore, the crux of this
principle includes modeling how to accomplish the goal of the lesson with the opportunity of supported practice (CAST, 2018).

Another important framework in education are the standards supported in instruction. For mathematics education there are the Standards for Mathematical Practice (SMP’s) which describe the skills that are based on “processes and proficiencies with longstanding importance in mathematics education” which educators of mathematics ought to seek to develop in their students (Ohio Department of Education, 2023) There are eight SMP’s which function as general principles in mathematics education and they are designed to mature with content. For instance, the first SMP is “make sense of problems and persevere in solving them” and then for seventh grade specifically they are expected to “solve problems involving ratios and rates and discuss how they solved them” along with multiple other specific curriculum based instances where a seventh grader is expected to make sense of a problem.

**Methods**

In order to quantify the data to fulfill my research question I used a resource created by Bowling Green State University Faculty, including Dr. Brooks Vostal, called Measuring Universally Designed Lessons (MUDL). The MUDL codebook explicitly indicates actions that express each component of UDL. For example, it specifies that to optimize individual choice and autonomy, students must be given a choice in one of six very specific ways, participate in designing the task, or set their own personal academic or behavioral goal during a lesson in order to consider that UDL guideline to be met. The MUDL codebook repeats this process for all thirty-one UDL guidelines published by CAST. This has been a necessary asset to my research because as I evaluate a lesson plan I can count the number of explicitly stated actions met
throughout the lesson in order to quantify the prevalence of each UDL guideline and the prevalence of UDL overall.

The process that I used to conduct and organize my research is as follows: First, I determined a grade band to focus my evaluation of the ARCs on. Since my specialization and education at BGSU falls within the grades of seventh through twelfth grade mathematics education I chose to only evaluate the lessons under this category. The NCTM has sixteen “Activities with Rigor and Coherence” intended for seventh through twelfth grade students published. Second, I read thoroughly through each individual lesson and evaluated the prevalence of UDL guidelines explicitly stated by the MUDL codebook. I organized my findings by printing out a copy of the CAST published UDL guidelines and circling the specific guideline as I saw it displayed in the lesson. Then, on the back of the sheet I described in detail how the lesson exemplified the guideline and which MUDL codebook example it directly aligned with.

After completing my sixteen lesson evaluations. I recruited two peer evaluators in order to ensure the accuracy of each lesson’s evaluation. The considerations that I employed in choosing my peer evaluators was that they were specialized in seventh through twelfth grade mathematics education. I additionally considered their level of competency in the Universal Design for Learning by choosing who had completed the BGSU course on Teaching Students with Exceptionalities. My final considerations when choosing my evaluators was their credit level and affiliation with the honors college, in best case scenario I was looking for evaluators who were of senior status by credits and in good standing with the honors program. I was able to find two peers who fit every criteria that I intended for a peer evaluator. Then, I requested their participation in my project, explained its objectives, and provided information on the sources rooted in the project. Each evaluator was then trained to explicitly follow the guidelines outlined
by the MUDL codebook to quantify the prevalence of UDL in each lesson. Each evaluator was given a month to complete their respective evaluations in accordance with the organization that I have outlined in the previous paragraph. After this period the peer evaluators compared their findings to my initial evaluation of each lesson.

![Initial Agreement](image)

**Figure 2: Note:** The column denoted “Y” represents the number of UDL elements I initially recorded. The column denoted “N” represents the number of elements that I did not initially record. The column denoted by “B” represents the number of elements that I had recorded but altered in order to improve precision in the final agreement. The column denoted by “N/A” represents the one ARC lesson plan that did not fall under any of the previous categories because there were zero occurrences of UDL in the lesson.

During our agreement meeting (see Figure 2) we determined that thirty-eight of my initial UDL examples were explicit enough by the standards of the MUDL codebook to be considered as UDL occurrences for the purpose of my research. Additionally, we added five instances that I
had not listed to our full list of UDL occurrences. The reason that my original evaluation was altered to this degree was because during our meeting, if all three of us did not agree instantly that the occurrence was explicitly outlined by the MUDL codebook we would not count it. So, multiple of each of our initial occurrences were cut to ensure complete agreement. I wanted to avoid any instances where someone had to convince anyone of an example which is why we cut several of each of our initial observations.

When one of our initial observations was cut, it was very common that we agreed the instance was either closely related to a UDL checkpoint but too vague to be considered explicit or related to a different facet of education. To be more specific on the latter, when we determined an initial observation was not fit to be considered a UDL occurrence we most often agreed that the example was highlighting either a standard for mathematics practice or promoted generally good teaching strategies.

Another consideration that went into our final agreement was whether the checkpoint associated with each instance was the most accurate. For instance, there were a few occurrences that two or more of us shared as examples of UDL, but we had associated the occurrence with different checkpoints. Some of the checkpoints are similar or were interpreted differently upon initial interaction which allowed for the three of us to initially agree partially in the sense that the instance did represent a UDL checkpoint, but we disagreed on which checkpoint was being represented and had to consider the most precise and accurate checkpoint being exemplified by the occurrence. To provide a specific example, in the first lesson plan, I had initially listed an instance of checkpoint 2.1, “clarify vocabulary and symbols” when the lesson plan stated to introduce “pi” using simpler words as part of the circumference and diameter ratio. Meanwhile, one of my peers noted the same facet of the lesson plan as an instance of checkpoint 3.2,
“highlight patterns, critical features, big ideas, and relationships”. After consideration, I agreed with my peer and that her initial interpretation was more accurately representing the situation, then the third evaluator determined that they agreed. Another example of this but reversed was when a peer stated on lesson number three that providing a graphic organizer was an example of checkpoint 3.4, “maximize transfer and generalization”. I had also listed providing a graphic organizer as UDL, however, I considered it an example of checkpoint 3.1, “activate or supply background knowledge” due to the type of graphic organizer being provided. I plan to include all of the details about my peer evaluation agreement meeting in this section, including our initial agreement, points that were debated, and the final agreement.

Results

The results of my research are depicted by the evaluations that I conducted on each lesson of the Activities with Rigor and Coherence from the grade bands of seventh through twelfth grade. To determine if an instance was considered an occurrence of the Universal Design for Learning I followed the guidelines outlined by the MUDL codebook. After evaluating the ARC’s I had listed fifty instances of UDL. In order to promote accuracy and precision in the results, my peer evaluators and I met to determine agreement and reach a conclusion on the amount of occurrence of UDL in the sixteen lesson plans.
Figure 3: Note: E = engagement, R = representation, A = action and expression

The three UDL principles (see Figure 3) represent the UDL framework most broadly. Within the ARC’s the principle of multiple means of representation is most prevalent, followed by multiple means of engagement, and then multiple means of action and expression. Examples of UDL falling under the heading of representation occurred twenty-four times in the ARC’s, which accounts for forty-eight percent of all examples of UDL. Meanwhile the relative frequencies of the other two principles were twenty-eight percent for the engagement principle and twenty-four percent for the action and expression principle.
Figure 4: Note: The columns represent the UDL guidelines. There are nine total but only guidelines one through eight appeared throughout the ARC’s.

The nine guidelines of the UDL framework (see Figure 4) represent the occurrences of UDL less generally than the principles previously stated. The most prevalent guideline was three, which is “provide options for comprehension” (CAST, 2018). This guideline falls under the principle of representation and accounted for thirty-four percent of all the UDL guidelines occurring within the ARC’s. The least prevalent was nine, “provide options for executive functions” (Cast, 2018). There were zero instances of guideline nine.
Figure 5: *Note:* The columns represent the checkpoints of UDL. There are thirty-one individual checkpoints but only the twenty shown above appeared in the ARC’s.

The thirty-one checkpoints (see Figure 5) are the most specific way to examine the examples of UDL within the ARC’s. The most prevalent checkpoint was 3.1 which is “activate of supply background knowledge”, it falls under guideline three and the principle of representation (CAST, 2018). Checkpoint 3.1 occurred seven times which means it had a relative frequency of fourteen percent of all the checkpoints within the ARC’s. The second most prevalent checkpoints, each with six instances in the ARC’s with relative frequencies of twelve percent of the data, were 3.2 and 7.3. There were eleven checkpoints that were not represented at all: 8.1, 8.4, 9.1, 9.2, 9.3, 1.2, 2.2, 2.3, 3.4, 4.2, 6.1.
Standards for Mathematical Practice

Before conducting my evaluations, I would have inferred that there would be a correlation between the appearance of UDL guidelines and the standards for mathematical practice. I assumed, because some of the UDL elements relate to the SMP’s, that the ARC’s with many examples of SMP’s would have many examples of UDL.

Figure 6: Note: The x-axis represents the amount of SMP’s within each ARC lesson. The y-axis represents the number of UDL elements within each ARC lesson.

However, after conducting the evaluations I see that there is no correlation (See Figure 6) between the SMP’s and UDL within the ARC lessons. Figure 6 shows that there is no association because the two variables do not provide a linear relationship when compared. If there was an association between the two variables then as the number of SMP’s was increasing the number of instances of UDL would also increase. Since this is not the case, we can infer that the two variables do not affect each other. For example, in ARC lesson two, there were two SMP’s identified and eight instances of UDL identified; in ARC lesson seven, there were four SMP’s identified and two instances of UDL identified.
Discussion

From the evaluations it was clear that the Activities with Rigor and Coherence lessons displayed multiple aspects of the Universal Design for Learning. There were fifty UDL elements recorded throughout the sixteen ARC’s, which averages to 3.125 instances of UDL per lesson. However, the data also showed that there was a notable range of prevalence between the guidelines and checkpoints where certain ones were making up for large percentages of the relative frequencies and others were not occurring at all.

Considering the principles (see Figure 3) the implications of a high prevalence of providing multiple means of representations may be that the ARC’s support learner variability in comprehension and preception of information that the teacher presents to them. For example, this principle is noted to support students with sensory disabilities, such as deafness and blindness, by offering representation in multiple forms – perhaps by providing visual and auditory delivery of information to students.

In consideration of the nine UDL guidelines, the high relative frequency of guideline three could imply that the ARCs emphasize the support of comprehension for learners. Providing options for comprehension refers to the process of progressing accessible information into knowledge to enhance future decision-making (CAST, 2018). Specifically this could look like comprehension being supported by focussing on foundational information and progressing the lesson into new ideas. For example, to support learners a teacher may highlight patterns, to the entire class, that the students are familiar with before they engage with a concept that is new to them.
The lack of UDL guideline nine “provide options for self regulation”, could imply a lack of support for the development of learners ability to intrinsically regulate their emotions and motivations throughout the lesson (CAST, 2018). This guideline represents a critical component of human development – the ability to effectively engage with one’s environment. The reason this guideline could be absent is potentially because the ARC’s focus heavily on mathematics content and are more vague in their educational strategies. A teacher could use an ARC lesson, but add options of self regulations to the lesson for their students to support their ability to regulate emotion and motivation.

In consideration of the thirty-one UDL checkpoints, the high prevalence of Checkpoint 3.1 indicates that the ARC’s support the activation or supply of background knowledge. The CAST organization states that “Information is more accessible and likely to be assimilated by learners when it is presented in a way that primes, activates, or provides any pre-requisite knowledge” (CAST, 2018). This checkpoint intends to reduce barriers for learners who lack background knowledge that is necessary for comprehending new information and for students who have the background knowledge but struggle to recognize its relevance in context. The prevalence of this checkpoint could indicate that the ARC’s are reducing the barriers of prior knowledge by providing it for all students. An example of this checkpoint in classroom context would be when the ARC’s state in their lesson plan to have students create a “know, wonder, and learn” chart to activate the students background knowledge before providing them with new ideas.

Overall, the most prevalent category in each of the focuses – principle, guideline, and checkpoint make sense because they all follow from the same central focus. This focus implies that the ARC’s most frequently provided explicit instances where students' prior knowledge was
being activated, comprehension was supported, and multiple means of representation were provided.

**Standards for Mathematical Practice**

The lack of relationship between the number of SMP’s in a lesson and the number of occurrences of UDL could imply that having SMP’s in a lesson and focusing on standards in general does not necessarily provide access for learning. Having SMP’s identified within the ARC’s shows its level of strength in terms of content and focus on standard ability. However, to have a more effective strategy for teaching one should consider integrating both concepts when utilizing the ARC lessons – incorporating SMP’s and UDL would be the strongest lesson. The consideration of UDL elements shows strength in terms of students' access to learning and a focus on equity within a lesson. Therefore, generally, it is important to consider both; for strength in content it is important to consider SMP’s and for accessibility of information it is important to consider UDL.

**Limitations**

It is important to acknowledge the limitations of this research and therefore its results to consider potential impact. One of the limitations of this study is that the NCTM published ARC’s were not created to exemplify UDL. It is important to recognize this fact so as not to scrutinize the ARC’s for their effort since a high prevalence of UDL elements was never the intention of the ARC’s. Rather, this study was intended to consider the frequency of UDL despite the purpose not being to display effective usage of UDL.

Additionally, throughout the evaluation process, myself and the peer evaluators found that there were several opportunities for UDL to be factored into the lesson at points where the lesson had not explicitly described a UDL checkpoint but was vaguely referencing one. During
our final agreement meeting we saw multiple opportunities where the lessons could have stated an occurrence of UDL. This implies that there is opportunity to strengthen the ARCs in terms of their accessibility for learners to, but we could not count the instance as an example of UDL because of a lack of detail. This may be important when utilizing an ARC lesson because an educator has the opportunity to adapt the strength of accessibility to meet the strength of standards identified by the lesson as referenced in the previous section.

Another potential limitation of this research is that only sixteen lessons are currently available for the grade band that I was considering. This could have an effect on the outcomes of this research because sixteen is a relatively small sample size. So, humbly, I should note this research could be limited by the amount of lessons studied to create the data and implications of that data.

An additional limitation of this study is that I purposely did not evaluate the lessons at an elementary level. I predetermined that since my experience is with the grade bands of seventh through twelfth grade, I should only consider those grades during my evaluations. This could potentially limit this research because there is a total absence of data considering grades kindergarten through sixth that the ARC’s have published. Since the data within these grade bands could differ from the results of this study, future research should consider this.

**Future Research**

This research could be replicated with further components by repeating the evaluation steps, but with consideration of all of the ARC published lessons. This would include grades kindergarten through twelfth grade and could potentially display altered results. Additionally, in this research I displayed the results and their potential implications, however a measure of inclusivity is not determined. In lieu of this point, Future research should consider the degree of
UDL necessary to be considered an inclusive lesson. Utilizing this information could effectively aid in supporting inclusivity within a lesson by declaring a number of UDL elements to be considered satisfactory.

As a preservice teacher I believe that this research will help to develop and strengthen my ability to implement a universal design for learning in my lesson plans and for my future teaching. A published article with a center of attention on implementing UDL into lessons that meet educational standards explained that the consideration of UDL guidelines within the planning phase of a lesson allows educators to develop flexible methods of instruction preemptively with integration of support for diverse student backgrounds, ability-level, needs, and the students’ preferences to create lessons that are equitable and engaging for all students (Rao & Meo, 2016, p. 1). The research by Rao and Meo shows the importance of UDL within an inclusive education classroom, and is useful for comparing the ARC’s which are also focused on standard-based lessons. By creating a means of evaluation on the ARC’s, myself and others will have a basis for incorporating a Universal Design for Learning into their lessons as well as providing suggestions for improvement to lessons already created.

The desired outcome of this research and project is to be published with the NCTM as an effective evaluation and potentially recommend inclusive practices within their published lessons. Along with this is the aforementioned hope of driving professional organizations to consider inclusive teaching practices; this project could promote reflection of previously published works to be revised to be more inclusive. So, the continuation of this research would conceivably drive this point to a greater extent. Ultimately, I believe that putting a spotlight on the importance of inclusive teaching practices and publishing the evaluation with a professional organization will promote awareness and benefit mathematics teaching.
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