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Relationships between Universal Design for Learning and student understanding in an elementary math setting

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Differentiation is essential to effective teaching. Individuals have unique needs that must be considered so that they can build understandings and expand their learning. To prioritize inclusiveness, teachers must be able to provide equitable means for each individual to access learning. But, effectively differentiating instruction to increase student understanding can be a challenging, time-consuming, and complex process. Universal Design for Learning (UDL) is a framework for teaching that helps teachers to create flexible learning strategies, tasks, and tools that are accessible for all students. With this structure, differentiation is inherent in instruction since curricula is designed from the start with multiple options for learning. This action research examines the effect of UDL on student understanding in a fourth-grade mathematics class, with efforts to determine how UDL affects elementary students' understanding in individual subjects. Math was randomly selected as the first subject to investigate. Two units were taught for the span of the study, one in which UDL was not implemented and one in which UDL was implemented. Students were given a pre-assessment and post-assessment for each unit, and the difference in percentage between the two scores represented student understanding. After implementing specific UDL practices for fourteen lessons, the findings indicated that UDL did not significantly increase student understanding. Despite this result, observations revealed that student engagement seemed to improve. With these findings, the next course of action would be to conduct research on UDL and student motivation and engagement, and to repeat this study with a larger sample size. The methods in this study could then be applied to studying the impact of UDL on student understanding for other subjects at the elementary level.

Quality differentiation is easily overlooked and difficult to implement in teaching. It is time consuming and complex to create multiple levels of activities, worksheets, and questions for various groups of students. Yet, differentiation is necessary in order to ensure that instruction is individualized to meet the needs of all students. With inclusion becoming a top priority across society, it is necessary for teachers to provide all students with equitable opportunities to learn. Universal Design for Learning (UDL) aims

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to provide educators with a framework for teaching with which to develop tasks and tools that are accessible for all students. With this model, differentiation is inherent in instruction. Rather than having separate tasks and tools for different levels of learners, teachers provide a single task or tool that is flexible and appropriate for all levels of learners. Through action research, this study sought to answer the question: What effect does UDL have on student understanding in specific subjects at the elementary level? This is an important question to address, because it directly relates to teachers who are looking to improve and expand inclusion in the classroom. The action research process was used since the study focused on applying and analyzing UDL in an elementary classroom setting. The results are intended to help inform future use of UDL in instruction. This study focused on the effects of UDL on student understanding in a fourth-grade mathematics class. Here, student understanding is represented by the increase in performance from a unit pre-assessment to a unit post-assessment. This represents student understanding, because it measures both the skills and knowledge that a student has gained over the course of a unit.

Literature Review

Conventional Differentiation

In education, differentiation is one of the most important components of instruction. Each student has unique learning preferences that influence their ability to learn. In general, differentiation is understood as instruction that is catered to each individual learner, so that all students can access the learning material (Wattes-Taffe et al., 2012). With differentiation, the learning goal is not changed for students, rather the means by which they reach the learning goal is changed. Common ways that teachers differentiate instruction include creating questions at varied levels of difficulty, teaching multiple strategies, providing different means of assessment, providing varying amounts of scaffolding, and grouping students by ability (Ollerton, 2014). Specifically, in elementary mathematics, teachers commonly assign students different problems, teach multiple strategies to solve the same type of problem, or provide manipulatives for students to use.

Philosophically, differentiation aligns with aligns with a constructivist view of education, since it caters instruction to a variety of learning preferences in order to best help each student access information and experiences. This is based upon the philosophy of John Dewey, which touts that each individual constructs their own understandings through experience. These ideas were then honed by theorists like Jerome Bruner, who also took psychology into consideration. His ideas were influenced by psychologists such as Lev Vygotsky and Jean Piaget who emphasized the significance of cognitive development and social interactions in building understanding (Krahenbul, 2016).

Constructivist learning theory has resulted in an increased number of teachers who support student-centered learning. The focus of instruction in student-centered learning is to help students take ownership of their learning and to cater to individuals' needs and interests (Lee & Hannafin, 2016; Krahenbul, 2016). Differentiation is therefore a significant component of student-centered learning, because it prioritizes students as unique individuals and requires teachers to tailor their instruction to accommodate the differences of their students. Yet, differentiating instruction can be a time consuming and complicated process. It necessitates a deep understanding of content, teaching strategies, and the outcomes of student learning. Furthermore, it requires teachers to create and prepare additional materials, learning activities, and assessments. This makes UDL attractive because it is a framework which helps teachers implement inclusive learning strategies and create flexible learning tasks and tools that are appropriate for all students.

Universal Design for Learning

UDL is a research-based framework for teaching that was developed by the Center for Applied Special Technology (CAST) in the 1990s (Center for Applied Special Technology [CAST], 2010). The goal of UDL is to create inherently flexible curricula with accessible learning tasks and tools that accommodate all students. This means that teachers' instruction would automatically account for all students' varied needs. The UDL framework is comprised of three main principles: providing multiple means of representing information, providing multiple means for students to carry out and express their learning, and providing multiple means to engage students in learning (CAST, 2010). CAST (2010) presented these principles in conjunction with certain functions that are completed in different parts of the brain.

CAST (2010) also explained their principles by providing guidelines for each. The principle of representation can be enacted by providing options for perceiving information, understanding disciplinary language, and comprehending concepts (CAST, 2010). The principle of action and expression is exercised by providing options for physical movement, communication, and executive functioning (CAST, 2010). Finally, the principle of engagement is practiced by providing options for stimulating motivation, interest in a topic, and student self-regulation (CAST, 2010).

By integrating all of these components naturally in curricular design, UDL benefits educators by helping them to efficiently plan instruction that is appropriate for all students in the class. Conventional differentiation strategies require teachers to plan separate tasks and tools and to provide additional learning strategies for specific students. This can be costly in terms of time and resources. Alternatively, teachers who employ UDL create and plan flexible tools and tasks that are accessible for all of their students. Through UDL, educators can account for learners' individual needs, because UDL supports differentiated instruction through accessibility.

In 2002, CAST published the first research on implementing UDL in the classroom (CAST, 2018). Since then, other studies have been conducted testing UDL in various settings and for various subjects. A significant portion of these studies have considered UDL and students with disabilities. For instance, Johnson-Harris and Mundschenk (2014) found that UDL was effective in engaging and supporting students with behavioral disabilities, while another group of researchers found that technology-based UDL was a beneficial support for students with intellectual disabilities who were struggling with literacy (Coyne et al., 2012). In addition, studies have been conducted on the effectiveness of UDL for various age groups and different types of schools. Dalton and Brand (2012) found that UDL provided more accurate assessments of learning with young children. Smith-Canter et al. (2017) researched the application of UDL in public elementary, middle, and high schools and discovered that UDL resulted in more inclusive instruction. Moreover, another significant portion of UDL research has focused on the effect of UDL combined with science and technology. For instance, one study found that the online program, *Khan Academy*, was not significantly aligned with UDL guidelines (Smith & Harvey, 2014), while another study found that STEM instruction benefitted from the UDL framework for differentiation (Basham & Marino, 2013). Currently, there is limited research on the effects of UDL instruction in specific subjects at the elementary level. This is an important area to study since the findings would be relevant for the many general education teachers in elementary schools and any elementary teachers who specialize in a specific subject.

Methods

Participants

The study took place from January through March 2018 and was conducted in a public elementary school in the Midwest United States. The community in which the school is located was affluent and predominately white, as was the majority of the school population. Eleven randomly selected students in a fourth-grade classroom participated, nine of which were male and two female. None of the students who participated had an Individualized Education Program (IEP), although two of the participants had 504 Plans.

Procedures

The UDL strategies, tasks, and tools were implemented in conjunction with the *Bridges in Mathematics* fourth grade curriculum. Specifically, the study spans Units Four and Five, Unit Four being "Addition, Subtraction, and Measurement," and Unit Five being "Geometry and Measurement" (Baker et al., 2017). The pre-assessment for Unit Four was given before any lessons from the unit were taught. The post-assessment was then given after the final lesson of the unit was taught. This was repeated with Unit Five. No specific UDL practices were applied during either pre- or post-assessments for both units. This was due to a restriction requiring all of the fourth-grade classes to be assessed in a similar manner. Both units' pre- and post- assessments were almost identical so that students' understandings could be measured accurately. Unit Four was the control, during which no specific UDL practices were used during lessons. The control period spanned thirteen lessons. After the control period, specific UDL practices were applied for fourteen lessons in Unit Five. Table 1 details the specific UDL practices that were used and the corresponding UDL principles they align with.

The first step in determining the effect of utilizing UDL practices in an elementary math setting was to find the difference between students' unit pre-assessment scores and their post-assessment scores. Students' assessment scores were converted to percentages, and the difference in percentage was found from the pre-assessment to the post-assessment. The differences in pre-assessment and post-assessment scores were found for both Unit Four and Unit Five. The scores were then analyzed with a paired samples t-test in order to determine if the UDL practices affected the difference between students' pre-assessment and post-assessment scores. A positive difference between students' pre- and post-assessment scores would indicate an increase in understanding; the greater the difference, the more a student's understanding increased. A paired samples t-test was used because it measures differences between two sets of data. In this case, the difference spanned a student's learning over the course of a unit. Some limitations of the study are its small sample size and the brief time it spanned. Only eleven students participated in the study, and the group was fairly homogenous in that none of the students struggled significantly nor were exceptionally advanced in skills and knowledge. In addition, the data was only collected over a total of twenty-seven lessons.

Results

The paired samples t-test (N = 11), showed that the mean difference in percentage between pre-tests and post-tests decreased slightly with UDL instruction, with M = 52.45 without UDL (SD = 16.91), and M = 52.00 with UDL (SD = 19.18). However, this decrease was not a significant difference in student understanding with UDL instruction (t = 0.09, p = 0.46). Students who had a smaller increase in understanding without UDL also tended to have a smaller increase in understanding with UDL. This trend is revealed with the line of best fit (Figure 1).

Applying specific UDL strategies, tasks, and tools did not have a significant positive nor negative effect on student understanding in an elementary math class. The difference between students' pre- and post- assessments remained about the same whether UDL was used or not. Interestingly, for the unit in which UDL was applied, the differences between the pre- and post- assessments were slightly less. With these results, there are numerous considerations and limitations of the study that must be taken into account. One of these considerations is the difference in topics between Unit Four and Unit Five. Disregarding any use of UDL, individuals may have understood the content of one unit better than the other. However, if units with similar math topics had been used, then the pre-assessment of the following unit may have been skewed due to students being familiar with the concepts. Thus, it was determined that units with different math topics should be used for the study. The major limitation of the study was the sample size. When using a paired samples t-test, sample size is a significant factor in the results. This is because the test compares means. A larger sample size allows for a more accurate representation of the population, because the mean is more representative of a wider range of individuals. Since there were only eleven students participating, the mean only represented a small population of students.

UDL and Student Motivation and Engagement

Despite there being no significant effect of UDL on student understanding, this study yielded some interesting observations. These observations were gleaned from anecdotal notes taken during the unit where UDL was implemented. These notes began as general observations about student responses to UDL practices, but after a few days, there was a pattern of most observations being related to student motivation and engagement. This led to informally surveying students to gain additional insight on their attitudes and opinions about the learning tasks and content during the unit in which UDL was applied. These exchanges were conversational in nature to maintain a low-risk environment in which students felt free to answer honestly.

During the unit where UDL was implemented, students seemed to be more engaged and naturally motivated in learning. For instance, the majority of students projected enthusiasm for participating in learning activities and expressed a positive attitude when learning about geometry. Students who had not readily answered questions during discussions in the previous unit increased their participation and were more willing to make an attempt at answering questions. In addition, when asked their opinion about the topic, the majority of students responded that they enjoyed geometry. The difference observed in enthusiasm and motivation may have been a result of the difference in the math topics from Unit Four to Unit Five. In order to test the effect of the change in math topic, it would be best to use two or more units with similar content. The change in student enthusiasm and motivation observed reflects findings from a previous study that showed that middle school students' motivation was positively impacted by UDL (Sokal & Katz, 2015). Even if UDL practices had no significant effect on student understanding, it may be beneficial for teachers to employ UDL in order to motivate students and increase engagement.

Future Studies

In future studies, it would be beneficial to collect data for a greater length of time and from a larger sample. Collecting data from a larger population may also increase the chances of collecting data from a group with more mixed abilities. Teachers would benefit from knowing if UDL practices significantly increase understanding for students who are especially struggling with math. While UDL practices can benefit all students, the existing research showing the advantage of UDL for students with disabilities lends itself to further research on whether UDL is effective for increasing understanding in specific subjects (Coyne et al., 2012; Johnson-Harris & Mundschenk, 2014). It would also be useful to conduct studies in which UDL is used in creating and administering the pre-assessments and post-assessments for the unit with which UDL is applied. This would eliminate the limitation of students' scores being affected by non-UDL testing environments. Furthermore, it would be valuable to determine the effects of UDL in an elementary setting in other subjects besides math to include more structured study of the impact of UDL on engagement.

Conclusion

Overall, research continues to reveal that UDL practices are either positive or non-detrimental to student learning. Since differentiation is a necessary component of instruction, it is beneficial for educators to further the research on this framework to continue working on supporting all students, and providing equitable access to learning. Based upon the results of this research, it would be beneficial to continue implementing UDL practices in instruction. Specifically for this fourth-grade class, UDL did not significantly impact student understanding either positively or negatively, but resulted in an observable increase in motivation and engagement. Furthermore, continuing to employ UDL practices would allow for additional data collection and the opportunity to study whether UDL increases student motivation and engagement in an elementary math class. Since motivation and engagement contribute to a positive learning environment, it would be beneficial to collect data to see if UDL significantly increases motivation and engagement. For this study, data could be collected on student participation and perseverance in math and surveys could provide insight on student attitudes. It would also be beneficial to repeat this study and modify it to accommodate a larger sample size.

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Appendix

Table 1

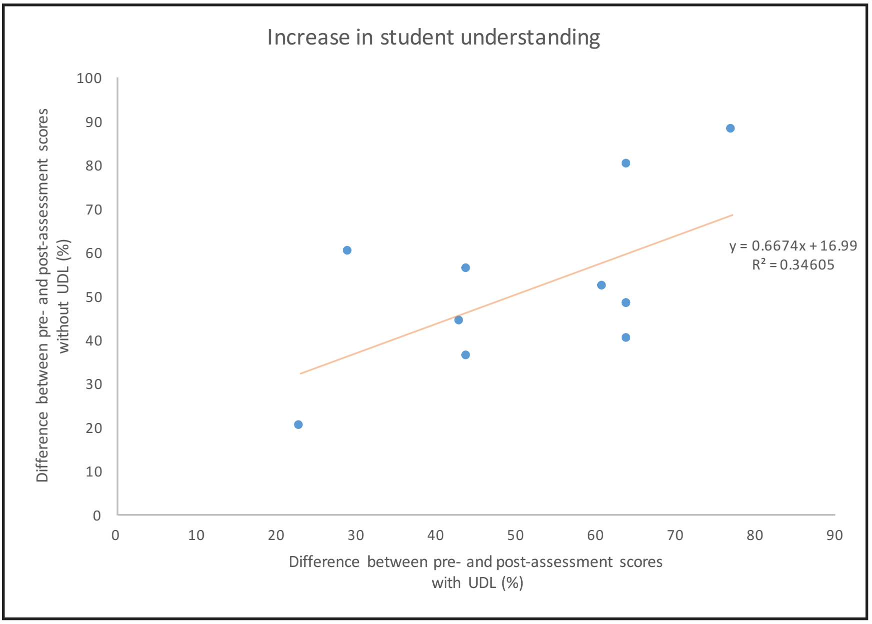
UDL Practices Applied During Unit Five

Bridges Lesson Title	UDL Strategies, Tasks, and/or Tools Applied	Aligns with… Principle 1	Principle 2	Principle 3
Introducing Angles	Visually representing angles by drawing them; saying the names of angles; moving arms to make angles	X	X	X
Benchmark Angles	Using multiple strategies to find the measures of interior angles (manipulatives, addition/subtraction, drawing diagrams)	X	X	
Angle Puzzles	Using multiple strategies to find the measures of interior angles (manipulatives, addition/subtraction, drawing diagrams)	X	X	
Sir Cumference and the Great Knight of Angleland	Visually representing circle terminology with drawings; students moving and arranging themselves to show circle terms	X	X	X
From Pattern Blocks to Protractors	Examples and non-examples of using protractors to measure angles			X
Introducing Parallel and Perpendicular Lines	Visually representing lines by drawing them; explaining types of lines; and moving arms to show types of lines	X	X	X
Parallels, Perpendiculars, & Angles	Using manipulatives and protectors to find angle measures		X	
Line Symmetry	Drawing symmetrical designs; folding paper shapes to find lines of symmetry		X	X
Polygon Detectives	Representing polygons with shape blocks; connecting polygons to objects in the classroom	X		X
Polygon Riddles	Drawing characteristics of polygons on whiteboards		X	X
Polygon Bingo	Using a familiar game structure to reinforce polygon concepts; visually representing polygons with drawings	X		X
Measuring Area	Visually representing area by drawing models and using manipulatives	X	X	
Measuring Perimeter	Visually representing perimeter by drawing models and using manipulatives; measuring perimeter of classroom objects	X	X	X
Area & Perimeter Formulas	Varied levels of scaffolding in problems using formulas	X		

Note. This table lists the specific UDL strategies, tasks, and tools that were applied during Unit Five, for fourteen lessons. An "X" indicates which UDL principles the practices aligned with, Principle 1 considering representation of information, Principle 2, expression of learning, and Principle 3, engagement.

Figure 1

Increase in Student Understanding



Note. UDL did not significantly increase, nor decrease student understanding measured by the difference between a unit pre- and post-assessment (t = 0.09, p = 0.46). Students who had a greater difference between their pre- and post-assessments for the unit without UDL, also tended to have a greater difference with UDL.

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