Implementation of UDL in a Low-Tech Math Classroom at Primary Level and its Outcomes

By

Arfa Anwer Arain

2018-MS-ITL-277393

Supervisor

Dr. Safdar Abbas Khan

A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science in Innovative Technologies in Learning (MS ITL)

In

School of Electrical Engineering and Computer Science, National University of Sciences and Technology (NUST), Islamabad, Pakistan.

(September, 2020)

Approval

Approval

It is certified that the contents and form of the thesis entitled "Implementation of UDL in a Low-Tech Math Classroom at Primary Level and its Outcomes" submitted by Arfa Anwer Arain have been found satisfactory for the requirement of the degree

Advisor : Dr. Safdar Abbas Khan

Signature: ____________________

Date: 20-Aug-2020

Committee Member 1:Dr Adnan Aslam

Signature: ____________________

Date: 20-Aug-2020

Committee Member 2:Dr. Tahira Lashari

Signature: ____________________

Date: 20-Aug-2020

Committee Member 3:Dr. Fahad Javed

Signature: ____________________

Date: 22-Aug-2020

Dedication

Dedicated to my parents for their immense trust in me and their constant support throughout my academic life.

My sisters for their sincere guidance throughout the journey.

My husband for encouraging me to do the best possible and always boosting up my confidence.

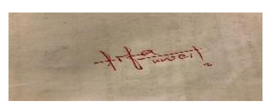
My best friend Mominah as she has been my constant support and provided me with better and genuine opinions.

Certificate of Originality

I hereby declare that the research paper titled "***Implementation of UDL in a low-tech Math classroom at primary level and its outcomes***" is my own work and to the best of my knowledge. It contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at NUST SEECS or any other education institute, except where due acknowledgment, is made in the thesis. Any contribution made to the research by others, with whom I have worked at NUST SEECS or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic is acknowledged. I also verified the originality of contents through plagiarism software.

Author Name: Arfa Anwer Arain

Signature: 

Acknowledgement

I would like to acknowledge the contribution of my supervisor Dr. Safdar Abbas Khan for answering my queries despite of his busy schedule.

My GEC member Dr. Tahira Lashari was a source of great help to me. I'm grateful to her for always responding timely on mails and always been available to me in person for meetings. Her knowledge in the field of my research was really useful to me at every step of my research.

I would like to thank Dr. Fahad Javed and Dr. Adnan Aslam for their timely response on e-mails whenever required and always being on time for attending defense and sharing their valuable feedbacks.

Lastly, I am really grateful to the authorities of the schools and College of Islamabad Model College for Girls (IMCG) for allowing me to carry out interventions and even supporting me in doing that.

Table of contents

Contents

List of Abbreviations

UDL- Universal Design for Learning

CG-Control Group

EG-Experimental Group

EdTech- Educational Technology

mAMAS- Modified Abbreviated Math Anxiety Scale

MA- Math Anxiety

List of Tables

List of Figures

Abstract

A traditional teaching methodology is an approach that doesn't take into account the variability in each learner in a classroom and their strengths and weaknesses that results in poor performance of the majority of students specifically in logical subjects like mathematics. Not only the conceptual understanding of students is compromised but also, the students face Math anxiety as a result of a lack of deep understanding and implementation of the subject. This causes an avoiding attitude of students towards math subjects or other courses that involves mathematical concepts. A new educational framework named Universal Design of Learning (UDL) includes every student in the classroom to learn irrespective of their background, disabilities, or learning preferences. The principles of the UDL framework include technology and pedagogy in a lesson plan that involves all the students in the classroom. In developing countries with low GDP being assigned to the education sector, technology integration is not possible in the short-run. The study examined the results of UDL implementation in a low-tech primary Math classroom. The results deduced that UDL could improve the conceptual understanding and reduce the math anxiety of students.

1. Introduction

1.1. Background

In the past times, every student was given instructions in the exact same ways and was considered as equality. But now, the instructors and researchers have found out the significance of learning styles. For many years, the educators have found that certain students favor some learning approaches more than others (Eisenberg, et al., 1991). Work on learning styles has shown the learning styles of students affect success in a learning environment (Akkoyunlu & Soylu, 2008). Direct teaching based on a 'one-size-fits-all' approach, therefore, cannot be successfully adapted to individual differences (Al-Azawei, Serenelli, & Lundqvist, 2016).

A new framework named Universal Design of Learning (UDL) was being introduced that could provide a curriculum and learning environment that could accommodate every type of learner without any discrimination. The idea of Universal Design came in existence in 1970s by Ronald Mace. It was first used only in designing products and architecture designs that are accessible to every individual despite of their different physical or psychological needs by being flexile in use and have tolerance for error. This idea was then adopted in the field of education, considering that every learner also have unique needs to grasp the ideas and concepts. So, in 1984, Center for Applied Special Technology (CAST) was founded from which Anne Meyer and David Rose gave a promising idea about the universal design for learning (UDL). In the start, their main aim was to provide flexible access to material and curriculum to the disabled children. It then evolved to a form of curriculum and instructional framework that is a help for all the students around the world to learn with their own pace and abilities.

The results of National Education Assessment System in 2014 shows that students are facing tough time in understanding even basic math concepts and that the students need extra attention in mathematics and science (Ailaan, 2017).

Using the UDL guidelines can transform a classroom from being boring and inapplicable to an interesting and engaging mathematics setting.

1.2. Motivation

Right now the condition of instruction in Pakistan is bleak. From many other major issues, the students face to meet the current pace of the world progress rate, one of them is that the education system has failed to develop the conceptual side of the students mind as they are running in the rat-race, trying to get good grades by cramming the outdated textbooks. Even if the students pass the exams and move to the next grade, their actual learning is far behind their grade level. The quality and access to education are the principle credits that Pakistan needs to apply to accomplish extraordinary monetary and social development (Xhaferri & Iqbal, 2010). A nation with first-class experts and pioneers without a supporting gifted workforce that makes up the majority of the economy is lacking to prevail in the advanced world (Xhaferri & Iqbal, 2010). The National education assessment system showed that grade IV students scored an average of 433 out of 1000 in mathematics (Ailaan, 2017). The overall poor performance of students depicts the problematic instructional environment in the class that doesn’t leads to the actual learning of the students.

Percentage of respondents	Mean score (out of 1000)
AJK (4 percent)	445
Balochistan (10 percent)	422
FATA (4 percent)	398
Gilgit-Baltistan (4 percent)	438
ICT (5 percent)	466
Khyber Pakhtunkhwa (17 percent)	423
Punjab (39 percent)	532
Sindh (17 percent)	416
National Mean Score	461

Figure 1 NEAS 2014 mean scores in Math

The low learning outcome of students is a product of many factors that include the non-contextualized and poor quality content that is being taught with low pedagogical skills and without the material and activities required (Ailaan, 2017). Lack of innovation in teaching, the outdated curriculum, and the thing that students 'memories' the facts and experiments are causing the education system to collapse all together when it comes to quality education.

Technology acts as a catalyst for students to learn new things and help every individual with their personalized and customized needs, but for the developing countries like Pakistan, it is not an easy task to accommodate the technology in all the rural and specifically the urban areas of the country and to bear the maintenance and training cost that will come along with it. According to the World Bank data, government expenditure on education was calculated only 2.899% in 2017. Most of the schools are not even equipped with basic facilities, like desks, in the schools. 46% of the classrooms do not have desks and 24% do not have textbooks available to the students (UNESCO, 2007). With this situation, the short-run solution could not be the use of technology for every individual in the institutes. Hence, there is a dire need to bring innovation in the pedagogy in the classrooms at all levels.

This prevailing situation in the classrooms from which almost every student is suffering and putting their future at stake was the main motivation to bring forward the idea of Universal Design for Learning (UDL) that could be a cause of betterment for the learning of every type of learner in the classroom.

1.3. Overview of Research

The purpose to conduct this study was to check the effectiveness of UDL on the conceptual understanding and Math anxiety of students in an environment where there is not much assess to technology. The application of UDL was mainly focused on the pedagogy instead of using technology. UDL is applicable to all types of students, so the targeted characteristics were the primary class mathematics students with different learning styles.

To check the outcomes of students' conceptual understanding and the difference (if any) of students' Math anxiety level after attending the UDL classroom, the Quasi-experimental study was best suited. A pre-test of conceptual understanding and Math anxiety was conducted on two groups of students from which one was experimental and the other was controlled group. The strength of both the groups was 25 each. The interventions of a class with the application of UDL principles were applied to the experimental group whereas the control group was given instructions in the traditional classroom environment.

The results showed a clear difference in the learning outcomes of the EG And CG. The performance of the EG in conceptual understanding was much better than the one of CG. The tests to check the quantitative data were applied to the software, SPSS statistics 20. Apart from conceptual understanding, the Math anxiety test also showed that the average anxiety score of

EG was lesser in the posttest than the CG. These results were a verification that UDL implementation does improve the learning outcomes in math and lowers the Math anxiety.

2. Literature Review

2.1. Concept of UDL

In every classroom, we observe diverse types of learners. Each student has a different way to grasp a concept and to memorize it and so, the Universal Design for Learning (UDL) strives for the flexibility in which the knowledge is being represented, the pathway in which a student does action and expression and ways to keep students motivated in what they learn (Rose & Meyer, 2002). The concept of UDL was introduced from the idea of universal design in architecture in which the structure was designed such that it could accommodate every type of individual that might have special needs as well (Hall, Strangman, & Meyer, 2003). If people have different physical needs, they all also need different learning environments as per their learning styles. The concepts of differentiated instructions and UDL are deep-rooted in the educational theories and researches that were held years back, like the concept of Lev Vygotsky (1978), and the zone of proximal development (ZPD) is also the part of DI and UDL (Hall, Strangman, & Meyer, 2003) The student who needs different ways and time to understand a concept does not mean that they are always disabled, rather, UDL benefits everyone in the class. UDL is accessible for every type of learner in a class whether they have disabilities, all levels of background knowledge, different IQ levels, and learning styles (Rose & Meyer, 2002). It is a challenge itself to involve diverse learners with different needs and wants in the same classroom. The principles UDL that are followed in the classroom has three main components that would facilitate the three brain network and there are multiple means of action, multiple means of expression and multiple means of engagement (CAST, 2018).

CAST (2018) described the principles of UDL as below:

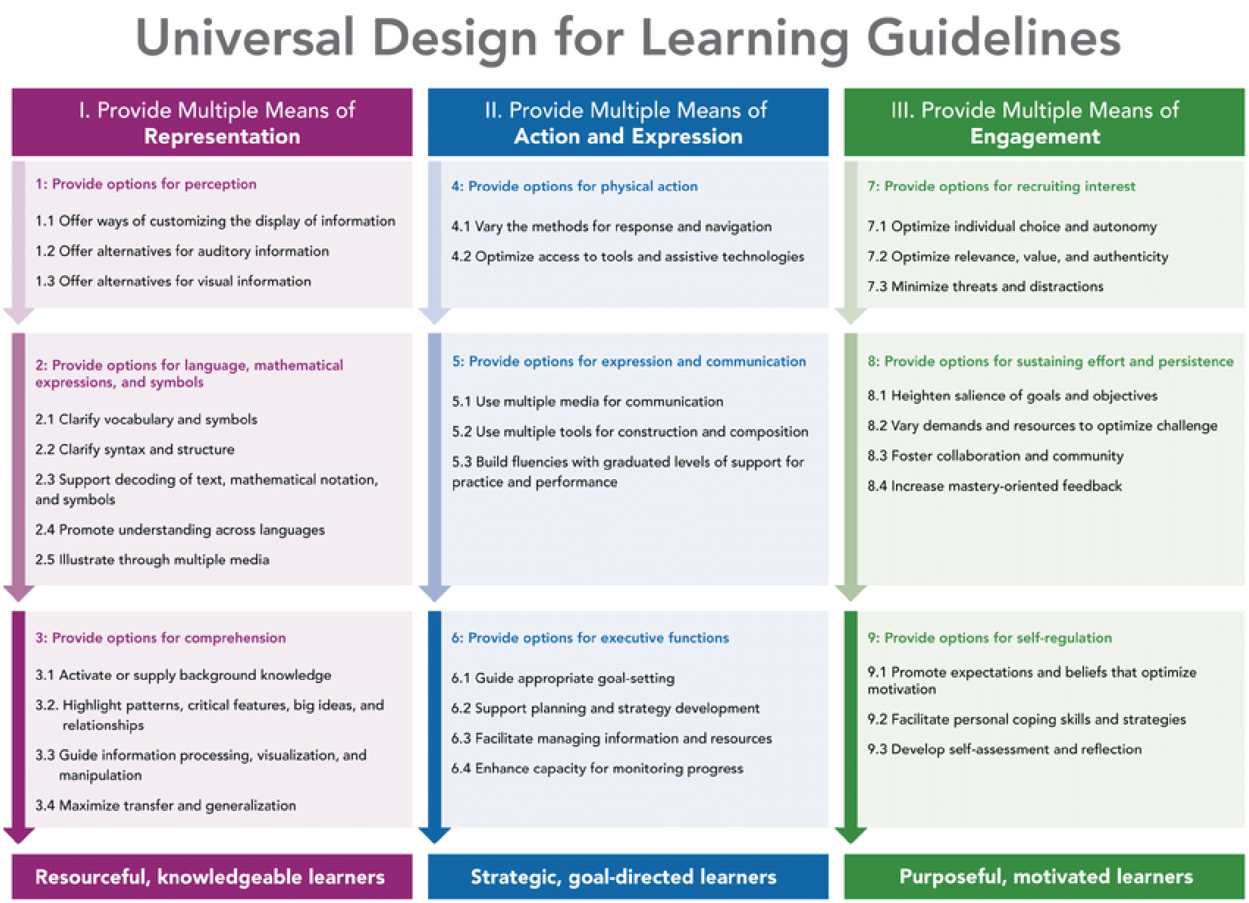


Figure 2 CAST image of UDL principles

2.1.1. Multiple Means of Action and Expression

Multiple ways of action and expression allow learners to demonstrate what they have learned in different preferred ways. They might choose between writing and drawing their learning or using multimedia or recording to demonstrate their understanding. These options enable the learners to choose the way of representation of their understanding more accurately and thus removing the barriers.

2.1.2. Multiple Means of Representation:

It refers to multiple ways in which the content or information is being represented to the students and that includes the assessments too. These could include charts, graphs, videos, images, demonstrations or objects to manipulate. It allows students to grasp the concept from different angles and helps them to remember it in the long run. All types of learners could benefit in the classroom when they are exposed to a number of ways through which they could understand the ideas.

2.1.3. Multiple Means of Engagement

It focuses on enhancing motivation and persistence. To keep them motivated, they should feel challenged, but not overly challenged. The information should be relevant and contextualized to make the learners indulged in what they learn. The assessment ways should provide them with a variety to reduce anxiety.

2.2. Math proficiency

Math is a universal science that helps in building other sciences and disciplines and that is why the knowledge of math is important at every stage of education (Apipah, Kartono, & Isnarto, 2017).

In the late 20th century, a lot of research was being done on what is the actual meaning of the word ‘Mathematics power’. After thoroughly investigating what mathematical skills are required in the world today that is needed to be implemented for the innovation and extensive study of the cognitive psychology and mathematical content, the term that was most accurate to describe the mastery, command and knowledge is ‘Math proficiency’ (Kilpatrick, Swafford, & Findell, 2001).

According to Kilpatrick and Swafford (2001), math proficiency has five strands that are all interdependent and students should have a command on all the five strands from early ages so they don't miss out the base of mathematics and should be proficient in math. The five strands are explained by Kilpatrick and Swafford (2001) as follows:

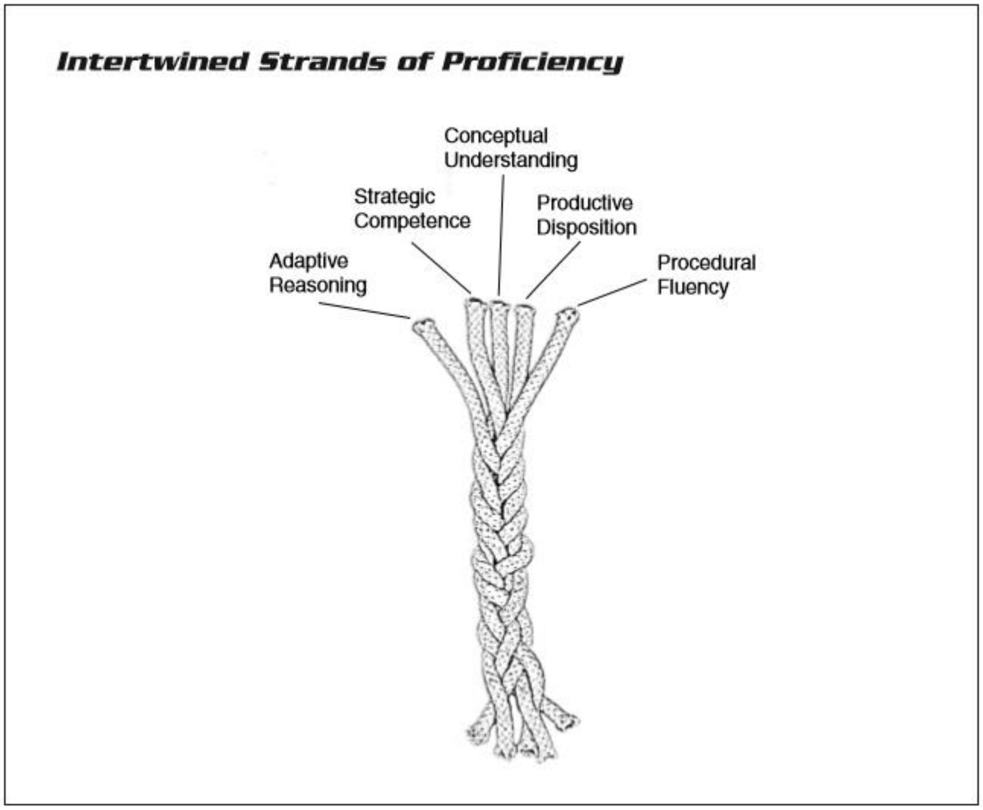


Figure 3 five strands of Math Proficiency

2.2.1. Conceptual Understanding

The conceptual understanding leads to a deeper understanding of the numbers and their connection with each other. Students with mathematical understanding know more than disconnected realities and strategies. They know the practical implementation of the concepts they understand and in which situation they are applicable. The Mathematical connection is important as it helps students to understand the connection between two discrete ideas in math that results in a deeper and ever-lasting understanding (Midgett & Eddins, n.d.). The deeper understanding of different concepts makes them able to see a clear picture as a whole of how they are interlinked. Conceptual understanding additionally bolsters maintenance. Since the ideas and concepts are indirectly connected to each other that's why it can easily be recalled once forgotten. Students are unlikely to forget or recall incorrectly if they have already comprehended an idea or method. They know the reason behind their calculations and mathematical operations. Students with a great conceptual understanding can go in-depth with the idea and can also see the mistakes in it if there are any. One math problem could be solved using different approaches and the one with clear concepts can represent the solution in more than one ways. The more a student could interlink different concepts that seem disconnected to a naïve, the more they have strong concepts.

2.2.2. Procedural Fluency

Procedural Fluency fundamentally alludes to quickness and accuracy in performing numerical tasks. It is the "knowledge of procedures… and skills in performing them deftly, precisely, and effectively". This incorporates familiar paper and pencil calculations as well as mental calculations. Students with a good conceptual understanding of Math ideas would be more fluent and accurate in doing the procedures and they will tackle different situations of a given mathematical operation to be applied as compared to the one who is just familiar with the procedure. This is how the conceptual understanding and procedural fluency are linked with each other. The procedures performed on the paper are mostly standardized but the mental calculations depend on how the individual applies rules and methods to make it quick and precise because in that case, the requirement is the end result. The procedures have steps in it that could be developed by the one with a conceptual understanding of the idea and such procedures could solve all the range of problems instead of just one problem. Also, the procedures could be modified correctly to make it easier and more concise.

2.2.3. Strategic Competence

Strategic competence refers to "the ability to formulate mathematical problems, represent them, and solve them". When an individual is encountered with a situation that needs a solution, the first thing is to identify the problem in it, represent it mathematically and figure out the approach to find its solution. In school life, mostly the problems are clearly stated that need solutions so the students doesn't have to struggle much in identifying the problem but in real life, they have to use their own mind to find out the actual problem and the strategy required to solve it. Reaching this level of clarity requires a lot of experience and practice. The first step to do when one encounters a problem is to make a clear picture of the situation in the mind. The clarity of mind is crucial to start solving. The next step is when the student picks out the important numbers and variables that will be required to further solve the problem.

It is easier for people to solve routine problems. Routine problems are the ones that they exactly learn in the classrooms and they can solve it easily when comes across one (might just with the change of digits). Solving routine problems doesn't even require them to create a mental image to solve it as they already know exactly what to do.

On the other hand, in real life, they come across a non-routine problem. A non-routine problem requires them to understand the problem by creating clear visuals in their mind and then start to solve. The operations used to solve the non-routine problems are exactly what they learned in the classroom but now it requires strategic competence to apply those operations and find the answer.

Problem-solving overlaps with the fifth strand of mathematical proficiency i.e. productive disposition, as it involves the belief that the application of mathematical procedures is the solution to the given problem.

2.2.4. Adaptive Reasoning

Adaptive reasoning is the justification of the steps that you used to solve a problem and the answer that comes after solving it. In other words, it is knowing why you are doing what you are doing. Adaptive reasoning is a very important strand in mathematical proficiency as it acts as a glue between all the other strands. At first, the expression "logical thinking" was considered to characterize the fourth strand. Be that as it may, it is a lacking term as different kinds of thinking are significant for complete numerical capability, including inductive, deductive, and conceivable thinking.

According to the research, the following three conditions leads to the development of the quality of adaptive reasoning in students: they have an adequate amount of knowledge required as a base to understand complex concepts, the level of difficulty of the assignment given should be clear and understandable for students and motivating and the task is contextualized (Soloway, Lochhead, & Clement, 1982)

2.2.5. Productive Disposition

Productive disposition is the belief in an individual while doing and understanding math that it is worth understanding and it does have a use in the real world. This strand in math proficiency is really important in order for the other strands to be strong. A student strives to have conceptual understanding, strategic competence, and adaptive reasoning when he believes that it will be beneficial and applicable to solve the real problems outside the notebook.

The productive disposition also develops when the other strands of Math proficiency develop. With the application of strategic competence in the non-routine problems and understanding of the concepts behind each step in the procedures to solve a question, the belief that mathematics is a logical and useful subject becomes more and more strong and hence the productive disposition develops.

2.3. UDL Brain Networks and Math Proficiency

UDL guidelines targets different brain networks of learning. It keeps the sequence of flow of information in consideration and then designs the instructions that could make the delivery of information as per the human brain requires. The sensory information is received from the back of the brain (recognition network), makes sense of the information received from the center of the brain (affective network) and organize it in the frontal lobes so that it could know how to respond to the received information (strategic network) (CAST, 2018).

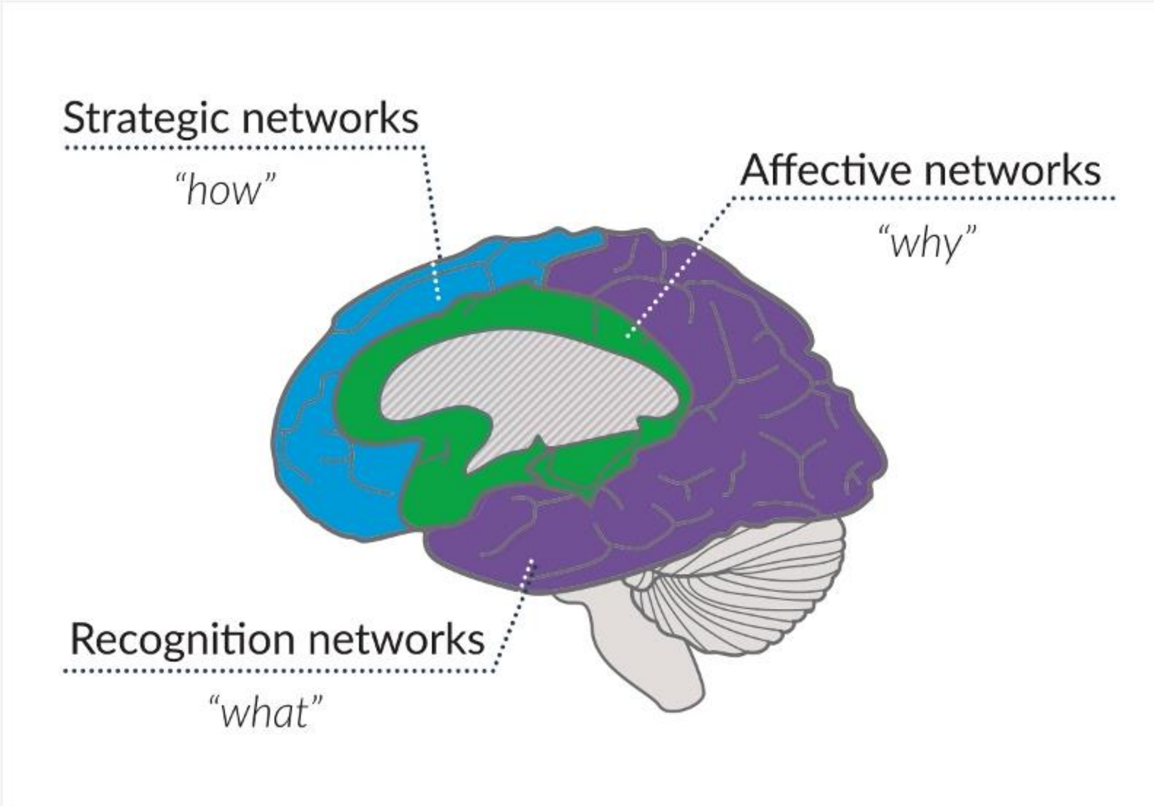


Figure 4 CAST: UDL and the Learning Brain

Different brain networks support different attributes associated with proficiency in mathematics i.e. conceptual understanding, Procedural fluency Strategic competence Adaptive reasoning and Productive disposition (Hunt & Andreasen, 2011). According to Hunt & Andreasen (2011), the three UDL principles are designed as per the learning requirenments of the human brain and is explained as follows:

2.3.1. Recognition Network

As per UDL guidelines, the instructions should be presented in multiples ways to the students rather than just one standard way. Every student has different strengths and weaknesses in learning and their brain learns more when the information is provided how their brain gathers information. Alternative modes of representing the content will enable every individual to learn no matter what their strength is. The recognition network of the brain gathers facts and classifies the words, letters, numbers, and the styles of representation. So, for the conceptual understanding of students, it is really crucial to give multiple options to the recognition network of the brain to develop deeper understanding according to the way the student's brain gathers information and removes the barriers to effective learning.

2.3.2. Strategic Network

Strategic network work with the 'how' of learning. When the brain perceives a concept, it is then designed to make strategies of how it will express the learning. The UDL principles suggest that an individual should be provided with multiple means of action and expression of their learning so they can express it in the ways their strategic networks created the strategies. Every brain is unique but, in the conventional teaching method, mostly the instructor wants the individual to express themselves in the written form. This could create a major barrier for students with disabilities or the one who faces difficulty in expressing their learnings in works and have issues with writing. The 'how' of learning also works for the strand of procedural fluency in math proficiency. It provide the skills that is needed to carry out the procedures fluently, flexibly, and accurately. Capacity for logical thought, reflection, explanation, and justification are also done by the strategic network of the brain. So, the adaptive reason is another math proficiency strand dependent on the strategic network of the brain.

2.3.3. Affective Network

Students are often found complaining about how they get bored in the classroom and their motivation level is often very low to attend classes. This is because they could not find any interest in the course content and how it's been taught in the traditional classroom. To gain students' interest, it is really crucial for the classroom environment to have multiple means of engagement. The activities, tasks, challenges, quizzes should be relevant to them and their surroundings. It should provoke interest and curiosity in the students and make them aware of why they are doing what they are doing. Setting an appropriate level of challenge for the students that they can accomplish with a little scaffolding could encourage and motivate them about their own capacity and abilities. This confidence in once own abilities would lead to productive disposition, which is the fifth strand of Math proficiency. This is how UDL considered the three brain networks that are essential to learning and then designed the UDL principles.

2.4. More about UDL

UDL promotes a student-centered learning environment by introducing more flexible learning techniques (Izzo, 2012). This idea of a student-centered approach is deep-rooted in the ideas of philosophers of education in history. Freire (1970) states that the role of a teacher is as a facilitator in the classroom where the students should construct knowledge on their own and investigate the already existing facts. This will lead them to become life-long learners. Vygotsky (1978), whereas, stated the social constructivist theory that students learn when they get to interact among peers and knowledge is constructed and retained in the process.

2.4.1. UDL Based Lesson Plans

Keeping the needs of students in the focus and then making a lesson plan is not a piece of cake and the teachers need to have a training session on how to design a curriculum and lesson plan that could benefit everyone in the learning space. After the completion of training session on how to design curriculum with integrating UDL principles in it, the lesson plans were more accessible for the students and it was able to cater more number of students than the lesson plan that was designed before training (Courey, Tappe, Siker, & LePage, 2012).

2.4.2. UDL and Technology

The learning outcomes of students using rich-technology in the math classroom were significantly higher as compared to the students with no use of technology (traditional teaching methodology) and that shows that technology plays a vital role in increasing the learning of students (Page, 2014). The understanding of students is higher when they are taught with the use of technology rather than in a traditional classroom, but the comparison of rich-technology classrooms with the class of the UDL framework could alter the results.

2.4.3. Hindrance in the Use of Technology

Technology plays an important role in making the learning customized and the cost of it is being reduced significantly, but the cost of maintaining, purchasing, and repairing the technology is something students, parents and institutes are concerned about (Technology in the UDL Classroom, 2017). Affording the cost of technology is a major concern that most of the institutes are concerned about. Integrating technology in the institutes that are accessible to all the students' needs a lot of funds. If there are not enough computers and internet connection in the institute that could accommodate all students of the classroom, the teacher won't be able to make the effective use of those computers (Sife, Lwoga , & Sanga, 2007). That is the main challenge the developing countries are facing for technology implementation. Many schools have outdated computers, poor software and internet connections that lead to frustration for the teachers to take benefit out of them but UDL based instructional design can also be achieved without the use of technology as well (Haris & Graham, 2012) They don't have enough of the GDP being allocated on education sector that would afford the cost of IT in institutes. Despite knowing its positive outcomes in the learning process, it's not a practical idea for them in the short-run as per their current capacity of funds. The use of edtech is not spreading as quickly in the developing countries as in the highly developed countries and most of the research about the use of edtech is also from the highly developed countries (TRUCANO, 2019). Not just the technology needs to be integrated into the institutes but also, the teachers need to be fully aware of its effective use in the classroom. It needs training of teachers to use edtech and make the most out of it. There are first and second-order barriers in the implementation of technology in the classroom where the first order is the lack of access to enough technological needs of the classroom, inadequate time to plan the instructions, keeping computers and other software in use and the second-order barrier is an unwillingness to change the classroom environment by using new pedagogies with the use of edtech and don't feel the need to integrate new ways to improve learning (Ertmer, 1999) .Teachers also need that courage, urge and motivation to bring change in the pedagogy and classroom environment according to the 21st century necessity. For the better performance of teachers in the classroom that could engage students, make them capable to cope with the future challenges of the world and create higher-order thinking skills, there is a need of pre-service training that would create more organized professionals and well-prepared instructors (Costin, 2017).

2.4.3. UDL and Pedagogy

There is a concept that UDL is about integration of technology in the classroom. No doubt that it could be one approach, but this is not always the case. UDL is not just the use of technology in the classrooms (King-Sears, 2009) (Rose & Meyer, 2002). It is also about the pedagogy and implementing different techniques and methodologies to make students grasp the concepts no matter what type of learner they are. It is not just the use of virtual manipulative technology but also the pedagogy that could clarify the concepts to students with or without learning disabilities (King-Sears, 2009). UDL provides students with resources, activities, and ways to deliver the content that is understandable for a greater number of students in the classroom. The learning is more inclined towards a student-centered approach than teacher-centered (Izzo, 2012). By providing appropriate multiple means of representation, action and expression, and engagement, the teachers should make effective use of UDL principles in the classroom in which the students' performance will increase and they will actively perform in the instructional activities (Kurtts, 2006). UDL creates a bridge between the students thinking capacity and the new things that they are learning. The UDL framework opts for all the possibilities that the students might require to learn and apply it to the students.

2.5. Learning Styles

Learning style is the way an individual prefers to learn a concept and that way is the most effective way for him (Bennett, 2015). James and Blank (1993) describe the learning styles as the most effective and efficient way in which an individual understands a procedure of learning a concept, stores and then recalls it.

It depends on a number of psychological and physical personality traits that impact how an individual sees, recollect, thinks, and resolve an issue (Bennett, 2015).

As UDL provides multiples ways of action, expression, and engagement, the students with any learning style could benefit more with a greater number of ways to grasp a concept. Presenting the content to students in only their learning style may decrease the effectiveness of the topic that requires other ways of representation too (Al-Azawei, Serenelli, & Lundqvist, 2016). There are around 70 theories and approaches discussing different learning styles (Mestre, 2012).

2.5.1 VAK Learning Styles Model

The idea of VAK learning style was first introduced in the early 1920s by the psychologist and child teaching specialist like Fernald, Keller, Orton, Gillingham, Stillman, and Montessori (Gholami & Bagheri, 2013). In this learning style model, it's made sure that all the senses of the students i.e. hearing, visuals, and tangible senses are involved in learning (Apipah, Kartono, & Isnarto, 2017). The learning style of students can be classified into three categories that are Visual, Auditory, and Kinesthetic learning styles (Kovac, 1999). The Visual, Auditory, and Kinesthetic (VAK) learning style is a popular learning style theory as it's used in all the learning, development and instructional fields and it tells in which way an individual prefers to understand an idea (Gholami & Bagheri, 2013). For applying VAK as a learning model on students, the steps involved are (1) preparation stage (2) Delivery stage (3) training stage and, (4) the Result preparation stage (Apipah, Kartono, & Isnarto, 2017).

2.5.2. Visual Learning Style

Some individuals prefer visuals when they want to learn something new or even revise old concepts**.** They take help from images, charts, graphs, videos, banners, pamphlets, different fonts, sizes highlights etc. to grasp an idea and learn concepts (Surjono, 2011). Visual learners focus more when they have a visual channel to learn something and that might include reading materials that they can read in alone time and concentrate more or an image with a message and deep information in it or might be a chart that provide statistical(Surjono, 2011) and numerical information (Gholami & Bagheri, 2013). The scores of VAK test can identify what type of learner an individual is. Teachers can prepare content for visual learners in the classroom so they couldn’t lag behind.

2.5.3. Auditory Learning Style

It is more effective for some individuals to understand things by listening to them. That helps them to create an image in their mind about how the idea works or the concept that they understand. The students who are auditory learners usually require oral directions to understand better and also, they want to engage in discussions, dialogues, and group work to retain information in their minds for a long time (Gholami & Bagheri, 2013). Listening is the key rule for them to memorize things and they will recall it as they heard it (Surjono, 2011). To benefit the auditory learners’ in the classroom, the instructor can conduct group discussions, deliver a concept via lecture in the class, and also be present to explain things verbally as well.

2.5.4. Kinesthetic Learning Style

Student with a kinesthetic learning style likes to perform and have hands-on experience to remember and understand the things. If they read an experiment in the book, they would like to perform it in order to understand. Lab activities, field trips, experiments in class, productive games and learning in the real world is how the kinesthetic learners learn because they want to feel, touch and hold the things they saw in a video or read in a book (Surjono, 2011). Kinesthetic learners are those who "implies total physical involvement with a learning environment such as taking a field trip, dramatizing, pantomiming, or interviewing" (Kinsella, 1995). For the instructors to support students with kinesthetic learning styles, they should arrange content-wise activities in the classroom to give them hands-on experience. Also, arranging field trips will help them see the things they read in books in the real-world as well, and then they could consider it a more useful thing to learn as-well. Such experiences will also give benefit to the visual learners and auditory learners' as-well when the instructor will demonstrate the experiences to the students.

2.5.5. How UDL Support Different Learning Styles.

The UDL principles promote multiple means of action, expressions, and engagement that has been designed after research on how the brain neural systems i.e. recognition, strategic and effective systems, work to learning new things (CAST, 2018). In a UDL classroom, apart from having a grip of the instructor on the math course content that is needed to be taught to students, it is equally important to have pedagogical skills to involve the diverse learners in the classroom (Hunt & Andreasen, 2011). In an inclusive classroom, UDL lesson plans can be beneficial for all types of learners and can meet the needs of diverse learners (Hunt & Andreasen, 2011). When a lesson plan is designed using the principles of UDL, alternatives are provided to students such as images, diagrams, videos, oral lectures, and graphs to grasp a concept and remain engaged (Courey, Tappe, Siker, & LePage, 2012). This principle, when applied in the classroom, will definitely help all types of learners to learn irrespective of their prior knowledge, learning style, or experiences. According to Courey, Tappe, Siker, & LePage (2012), to accommodate the diverse learners in the class and facilitate all learning styles, the students are provided with multiple means of action and expression to express their learning in a UDL classroom so that they can show it through their performance, verbally in form of a viva/interview or in written form as they are comfortable and more expressive. When students are given challenging questions and problems in math and other courses to solve, their strategic network in the brain activates and create strategies to solve the problem and those end result solution strategies could range from a descriptive report to applying procedures, depending on how the individual's strategic brain network worked out (Hunt & Andreasen, 2011). This shows that the UDL principles are great in taking care of the needs of all learners in a classroom.

2.6. Math Anxiety

A lot of researchers defined math anxiety in different ways. Math anxiety is ‘a feeling of tension and anxiety that arises when dealing with numbers and manipulations in everyday life and while doing math in the classroom ‘ (Hopko, et al., 2003). Math Anxiety is a distinct form of anxiety that occurs only when dealing with math problems and is different from other forms of anxiety (Carey, Hill, Devine, & Szucs, 2017). Students facing the math anxiety avoid math practice and the problems that requires cognitive processing (Ashcraft, 2002). Math anxiety interferes with the cognitive processing of working memory that results in poor performance (Ashcraft, 2002). Math anxiety is the reaction in the body when encountered with a math exam or when pressurized with the comparison of the math performance of other individuals (Posamentier, Smith, & Stepelman, 2010).

There is not a lot of research being conducted on the causes of math anxiety. The literature on the research shows that there is a link between MA and the teaching methodologies being used in the classroom (Finlayson, 2014). In the traditional classroom, the whole system is based on rote learning and memorization, where the teacher has all the authority and the student is just the receiver with no time and authority to question the content and curriculum (Finlayson, 2014). With this type of environment in the classroom where there is no autonomy for students to express in multiple ways nor does the teacher represents in multiple ways to provide options for diverse learners to learn, it causes MA. The research was conducted to check the grade level from where math anxiety arises. Jackson and Leffingwell (1999) found out that the MA starts as early as in primary grades. The reasons that they discovered were that the whole focus of the education system is on getting good grades and memorization rather than on the actual conceptual understanding of the students. This traditional learning environment is one of the prime causes of MA. In the traditional classrooms, 'one size fits all' rule is being applied and the teaching methodology doesn't take into account that there are different learning styles, abilities, and learning time pace of students (Boaler, 2009).

2.6.1. modified Abbreviated Math Anxiety Scale (mAMAS)

To check MA among children, a scale was developed that was appropriate and easy to use. Most of the scales already present were suitable for the use of adolescents or elementary grades students (Carey, Hill, Devine, & Szucs, 2017). Several scales were developed before mAMAS scale to calculate the MA among children, but they were very age-restricted as it asked specific math questions (i.e. there are 6 ducks in the grass. How many ducks are there in all?). This type of question would clearly be used for specific grade children and for the higher grade students it won't be able to check their anxiety level (Carey, Hill, Devine, & Szucs, 2017). This type of specific question scales to check MA were seen in Ramirez, Gunderson, Levine, & Beilock (2012) and Wren & Benson (2004). To check MA among students, another questioner was also introduced named Math Anxiety Questionnaire (MAQ) (Thomas & Dowker, 2000). The issue that was observed with this questionnaire was that it didn't show any relationship between MA and math's performance (Thomas & Dowker, 2000). The modified version of AMAS was developed for the fourth-grade students of primary classes and seventh and eighth-grade students of secondary classes (Carey, Hill, Devine, & Szucs, 2017).

The AMAS scale, along with other several questionnaires, was developed to check the MA among adults (Hopko, Mahadevan, Bare, & Hunt, 2003). The mAMAS test was created by modifying the language and content that is suitable for checking MA in children as well as a broad range of people belonging to different age brackets (Carey, Hill, Devine, & Szucs, 2017).

The mAMAS test is a nine items scale with each question having a five-point Likert scale that ranges from awful to brilliant feelings with a situation given involving math (Hopko, et al., 2003).

2.6.1.1. The Reliability of mAMAS Scale

The reliability of the mAMAS test was being accessed by using both ordinal and Cronbach's alpha. Cronbach's Alpha is one of the most frequently used indices to check internal consistency (reliability) (Zumbo & Rupp, 2004). The reason behind using ordinal alpha along with Cronbach's alpha is that the value of the latter decreases with a small sample size (Yang & Green, 2011; Sheng & Sheng, 2012). The Cronbach's alpha also reduces when the data is not normally distributed (Sheng & Sheng, 2012).

The reliability of the mAMAS scale as a whole came out to be 0.89 for N=1849 on the ordinal alpha, the most reliable measure to calculate internal consistency of the items scale and the subscales (correlated latent variables representing Learning and Evaluation) showed good internal consistency of both 0.83 (Carey, Hill, Devine, & Szucs, 2017). The value of Cronbach alpha for the overall scale was calculated as 0.85 (95% confidence interval 0.83–0.87) whereas for the subscales, it was 0.77 for the learning subscale (95% confidence interval 0.74–0.80) and 0.79 for the Evaluation subscale (95% confidence interval 0.76–0.83) (Carey, Hill, Devine, & Szucs, 2017).

2.6.1.2. The Validity of mAMAS

The confirmatory factor analysis of the mAMAS that was based on the two latent factors of the AMAS concludes that the two-factor analysis of the AMAS could also be applied on mAMAS (Carey, Hill, Devine, & Szucs, 2017). The factor loadings of all the factors were at an acceptable level of < 0.6 which suggests that the mAMAS test also have the same two subscales (learning and evaluation) as that of the original AMAS and this was the case for both younger and older children, making the scale used for a broader age range unlike the children MA scales (Carey, Hill, Devine, & Szucs, 2017).

3. Methodology

3.1. Overview

This study was conducted with the purpose of improving the mathematics conceptual understanding of students and to check their math anxiety level. The study was a Quasi-experimental design research. The study was mainly quantitative.

The research was conducted with the quest to find the answers to the following questions:

- How the UDL principles will impact the student's conceptual understanding of mathematics?
- Do the UDL principles create any change in the math anxiety of students?

The school where the interventions were carried out is a public school in Rawalpindi. Class 4 students were involved in the math classroom. One section was taken as a control group and another section was taken as an experimental group. The interventions were carried out on the experimental group only and the control group was taught from the traditional teaching methodology. The number of students in the experimental and control group was almost equal with 51.92% of students in the experimental group and 48.07% of students in the control group. To get the quantitative data of research questions one and two, a pre and post-test were conducted on both the groups. The data was being tested and analyzed using the SPSS 20.0 software.

The main purpose of conducting the interventions was to check whether the UDL based lesson plans were helping students in better grasping the conceptual understanding of the mathematical concepts or not. Besides that, is there a correlation in the conceptual understanding and the math anxiety level of the students or not.

3.2. Group Allocation

To check if the UDL based lesson plans implemented in the classroom have a significant effect on the conceptual understanding of the students and it's effect on the math anxiety of the students, Quasi-experimental design research was conducted on the primary class students.
The students of fourth grade were selected for the control and experimental group from the school of Islamabad model college for girls (IMCG), Korang Town, Rawalpindi.
For the purpose of fair comparison among the groups, two sections were selected from the same grade as experimental and control groups respectively. The selection of two grades of the same grade and school ensured that they had the same exposure to the content of mathematics.
As it is a girl’s public school, so the total strength was of girls from the fourth grade.

3.3. Group Size

The demographics of the control and experimental groups are shown in table 4.1 as follows:

Table 1 Demographics of Control and Experimental group

	Control group	**Experimental group**
Current education level	Fourth grade	Fourth grade
Total no. of participants	25	27
Gender	Females	Females

3.4. Procedure

3.4.1. Defining the Research Problem

This research was conducted with the purpose to check if applying UDL principles in a low-tech classroom could be beneficial for the students. Given the implementation of UDL with the use of different types of technologies including assistive technology in the previous researches, this research was conducted to check if the UDL principles applied in teaching without the use of technology are improving students' conceptual learning outcomes.

Research Question 1: how do UDL principles impact the conceptual understanding of primary class students in the low tech math classroom?

Research Question 2: Is there a correlation in conceptual understanding and math anxiety among students?

3.4.2. The Variables

The independent variable (IV) and dependent variables (DV) are defined as follows:

Independent variable: UDL based lesson-plans.

Dependent variable: conceptual understanding, Math anxiety.

For the research question one, the DV is conceptual understanding. For the second research question, DV is a math anxiety level.

3.4.3. Hypothesis

The hypothesis for the research question one:

Table 2 Hypothesis of Research Question 1

HYPOTHESIS	DATA COLLECTION
Hyp 0: Use of UDL principles as a pedagogy has no significant effect on the Conceptual understanding of mathematics for primary class students.	Pre-test and post-test design.
Hyp 1: Use of UDL principles as a pedagogy has no significant effect on the Conceptual understanding of mathematics for primary class students.	Pre-test and post-test design

The hypothesis for research question 2:

Table 3 Hypothesis of Research Question 2

HYPOTHESIS	DATA COLLECTION
Hyp 0: The change in the conceptual understanding of students does not have an impact on the math anxiety level of students	AMAS Math anxiety scale.
Hyp 1: The change in the conceptual understanding of students does have an impact on the math anxiety level of students	AMAS Math anxiety scale.

3.4.4. Choosing a Suitable Experiment

For the given research question, the most suitable experimental design is 'pre-test post-test nonequivalent group design'. This is one of the types of Quasi-experimental design research. The reasons for the applicability of this design are as follows:

3.4.4.1. Conducting a Pre-test:

A pre-test enables the researcher to know the level of knowledge the participants have on a particular area and checks if the students are in need of the interventions. This also allows the researcher to get an idea of where participants lack behind and how to design the interventions that could actually benefit the group.

In the present research questions, a pre-test was conducted on both the control and experimental group to check if the students have a conceptual understanding of the math topics on which they are going to receive the intervention and if they are facing math anxiety before the intervention.

The results showed that the students actually lacked conceptual understanding and most of the students showed math anxiety on the mAMAS math anxiety scale.

Every individual is a different type of learner. They learn more when they are provided with conditions that match their learning style. To know the learning style of every individual, they were given a VAK (Visual, Auditory, and Kinesthetic) learning style test. At the end of the test, they were told what their learning style is and the teacher kept the record of every student learning style for the purpose of making a lesson plan that includes every student need in it.

3.4.4.2. The Non-Equivalent Groups:

The Pre-test was conducted on the Control and the Experimental group. The purpose of conducting a pretest on the control group was to check what will be the change in the results in case no interventions were carried out on the group. The control group has almost the same number of participants and they have access to the same content and learning environment as that of the experimental group before carrying out interventions. This similarity will have a strong impact on the outcomes of the research.

3.4.4.3. Conduction of Post-Test:

The post-test was conducted after the interventions were conducted and the topics were covered that were given in the pre-test. The post-test was also given to both, the control and the experimental group. The results showed a significant difference in the performance of students when compared with their pre-tests and also a difference was seen in the results of the control and experimental group as well.

3.4.5. Testing Dependent Variables

A MCQs based test was designed that was given in the pre-test and post-test. It is made clear here that both of the tests (pre-test and post-test) were the same. It had 10 MCQs based on the topics that were selected for the intervention and it had maximum marks 10. Time of 30 mins was allotted for completing the test.

3.4.6. Planning and Carrying Out the Pre-Test for Conceptual Understanding

The test consisted of 10 MCQs based questions, each carried equal marks. The questions were from the topics of multiplication, division, and fractions. To check the students' conceptual understanding, the questions consisted of real-world scenarios in which either multiplication, division or fraction had to be applied (that wasn't mentioned) in order to get the answer. The language used was English that is their mode of instruction in the books but to remove the language barrier, the instruction translated all the questions in Urdu so the students who were having difficulty in understanding the question due to the language could understand it better.

While structuring the questions, the following rules were followed:

-the problems were from the real-world scenarios.

-They were contextualized according to the students' age, gender, interests, and social status.

-as the questions were of three concepts of mathematics (Multiplication, division and fraction), all the ten questions were shuffled and they were not in sequence of which concept will be followed next. In this way, they could not guess which mathematical operation to apply in the next question to get the correct answer.

The questions consisted of real-life situations from which the kids could relate as the class selected for the experimental and control group is of primary level. This test was to check the conceptual understanding of the students that when the math symbols are not given, how to interpret which operation will be applied.

3.4.7. Pre-Test for Math Anxiety

To check the math anxiety level of students, the Modified Abbreviated Math Anxiety Scale (mAMAS) was used. This test consists of 9 questions that were designed to check the anxiety of children with an age bracket of 8-13 years. Each question consists of a Smiley Face Likert scale as a rating scale for quantitative questions in evaluations. Students had to choose the face that best describes the feeling they get when they encounter the given situation. The most anxious feeling at the left most of the Likert scale was scored with 5 points and the brilliant feeling on the rightmost was scored 1 point. In this way, 45 was the highest score of anxiety in the overall test and 9 was the lowest anxiety score. The scale has subscales that further measures the anxiety about learning and evaluating math. Every student was given this test before the intervention started and the anxiety score of all the students was marked. This test was performed by both experimental and control groups.

3.4.8. Pre-Test for Learning Styles

A VAK test was conducted on students. Every student was given that test to perform. VAK test is easy for students of primary classes to comprehend. The test was in English and for further ease of students, the researchers translated the content in Urdu and further elaborated it as well. At the test, every student knew what their learning style was. The teacher kept the record of all individuals learning styles. This test was performed by only the experimental group.

3.4.9. Interventions Used in the Study

The interventions were carried out as followed:

Table 4 Schedule of Interventions

Total days of intervention	15 days
Each lecture time slot	35 minutes
Teacher delivered a lecture for the time period	10 minutes
Students activity time period	25 minutes
Topics covered in overall intervention	Multiplication, division, fraction

To make the classroom learning more inclined towards a student-centered approach, different activities were performed by the students that were relevant to their learning objectives. For the purpose of implementing UDL in the classroom following measures were taken place, keeping in view the UDL guidelines:

3.4.9.1. Using Principles of UDL (Universal Design for Learning)

-Principle#1 Multiple Means of Representation:

In the first 10 minutes of the class, the teacher delivered the lecture on the concept that the students were going to learn that day. The lecture consisted of the main learning goals that the students were supposed to achieve from the lecture and the activities followed. It also revised the basic concepts that were prerequisite of the new concepts the students were going to learn. To further clarify the symbols and vocabulary used in the theory, a word wall was created in the class soft board with the help of students that also included clear and simple images that clarified the concepts of students

The same concept was shown in the videos that had a storyline and taught students through animations, rhythms, attractive colors, clear and bold symbols and vocabulary that is understood for primary classes students.

Students were also given colorful printouts with images, vocabulary, and symbols of the respective learning aim.

-Principle#2 Multiple Means of Action and Expression:

Keeping in view the fact that every student needs different ways of learning, the researcher designed and asked the students to perform different activities and games for each concept. This would provide multiple dimensions for students to look at the lesson they are learning. Students were given options to perform in groups or individually. The rubrics of the content were provided that made them aware of how much they have already done and how much they have to do more to complete the activity.

Options were provided if they want to show their learning and performance in front of the class as a presentation or in written form. They were provided with different creative worksheets to show their learning. Also, the students were provided with material to perform hands-on activities that they could do individually and take help from their fellow friends. In the end, the answers were discussed in front of the class. The students showed how they did the activity and the researcher gave them feedback on their performance. Timely and constructive feedback helped them to improve their mistakes on-spot. The students were provided with different helping material (reading material, books, and leaflets).

-Principle#3 Multiple Means of Engagement:

Students were made clear about the learning goals at the start of the class. The researchers communicated the learning objectives of the lesson every time at the start of the class and it was repeated many times during the class as well to remind the students of the direction they are on. To engage the students, the content offered was contextualized. It was made by keeping in consideration the age, interests, and culture of students so they could relate and engage in the content. The feedback of the activities was provided timely and mostly at the time they completed the task. Scaffolding was provided by the researcher to the students when needed while they were doing the activity. The levels of challenges were increased with every intervention so they should feel challenged. The students showed keen interest in animated videos shown to them. They asked questions, discussed among the peers and showed a positive response. The students were told how the things they are learning are applicable in their everyday life and by learning those concepts, how much ease it would bring along in their day to day life. This motivated them to learn it as they knew the concepts are not just confined to the textbooks but also usable in their own lives.

3.4.10. Carrying-Out Post-Conceptual Understanding Test:

After the three weeks of interventions that consisted of UDL principles in the classroom, the students went through all the concepts that were given in the pre-test. They were given the post-test to solve in the time period of 35 minutes. The time period, questions and marking scheme of the post-test was exactly the same as in the pre-test. For pre-test and post-test, see Appendix A.

3.4.11. Carrying-Out Post-Anxiety Test:

The post-anxiety test was again the mAMAS test. The students of both, the experimental and control groups were given this test after 3 weeks. The purpose of this test after 3 weeks was to check if there is any change in the anxiety level of students who received the interventions (experimental group) and who were being taught in the traditional classroom (control group).

3.5. Data Analysis

The research design of this research is a Quasi-experimental research design. For analyzing the quantitative data gathered through pre and post-tests of control and experimental groups, the software that is used is SPSS 20.0.

4. Data Analysis and Results

4.1. Overview

The data was collected from the control and experimental groups. The following tests were conducted in order to collect the relevant data from the control and experimental groups:

Table 5 Pre-Test conducted in the EG

Pre-Tests conducted in the experimental group before intervention
Pre-Test for conceptual understanding
Learning style VAK Test
Pre-Anxiety Test (mAMAS Test)

Table 6 Post-Test conducted in the EG

Post-Tests conducted in the experimental group after intervention
Post-Test for conceptual understanding
Pre-Anxiety Test (mAMAS Test)

Table 7 Pre-Test Conducted in the CG

Pre-Test conducted in the Control group
Pre-Test for conceptual understanding
Pre-Anxiety Test (mAMAS Test)

Table 8 Post-Test conducted in the CG

Post-Test conducted in the Control group
Pre-Test for conceptual understanding
Post-Anxiety Test (mAMAS Test)

4.2. Data Collection

4.2.1. Pre-Test Data for Experimental Group (EG)

4.2.1.1. Pre-Test for Conceptual Understanding:

The descriptive statistics for the pretest of the conceptual understanding (CU) of EG is listed below:

Table 9 Descriptive Statistics for the Pre-Test of CU of EG

Descriptives

			Statistic	Std. Error
PRETEST1	Mean		3.60	.327
	95% Confidence Interval for Mean	Lower Bound	2.93	
		Upper Bound	4.27	
	5% Trimmed Mean		3.57	
	Median		4.00	
	Variance		2.667	
	Std. Deviation		1.633	
	Minimum		1	
	Maximum		7	
	Range		6	
	Interquartile Range		3	
	Skewness		.212	.464
	Kurtosis		-.776	.902

4.2.1.2. Pre-Test for Math Anxiety:

The descriptive statistics for the pretest of the Math anxiety of EG is listed below:

Table 10 Descriptive statistics for Pre-Test of MA of EG

Descriptives

			Statistic	Std. Error
PREANXIETY1	Mean		24.36	1.370
	95% Confidence Interval for Mean	Lower Bound	21.53	
		Upper Bound	27.19	
	5% Trimmed Mean		24.24	
	Median		23.00	
	Variance		46.907	
	Std. Deviation		6.849	
	Minimum		13	
	Maximum		38	
	Range		25	
	Interquartile Range		11	
	Skewness		.294	.464
	Kurtosis		-.708	.902

4.2.2. Pre-Test Data for Control Group (CG):

4.2.2.1 Pre-Test for Conceptual Understanding:

The table below shows the descriptive statistics of pre-test for the CU of CG

Table 11Descriptive Statistics for pre-test of CU of CG

Descriptives

			Statistic	Std. Error
PRETEST2	Mean		3.08	.365
	95% Confidence Interval for Mean	Lower Bound	2.33	
		Upper Bound	3.83	
	5% Trimmed Mean		3.04	
	Median		3.00	
	Variance		3.327	
	Std. Deviation		1.824	
	Minimum		0	
	Maximum		7	
	Range		7	
	Interquartile Range		3	
	Skewness		.096	.464
	Kurtosis		-.451	.902

4.2.2.2. Pre-Test for Math-Anxiety

The descriptive statistics for the pretest of math anxiety of control group is listed below:

Table 12 Descriptive statistics for the pre-test of MA of CG

Descriptives

			Statistic	Std. Error
PREANXIETY2	Mean		26.32	.860
	95% Confidence Interval for Mean	Lower Bound	24.55	
		Upper Bound	28.09	
	5% Trimmed Mean		26.50	
	Median		27.00	
	Variance		18.477	
	Std. Deviation		4.298	
	Minimum		17	
	Maximum		32	
	Range		15	
	Interquartile Range		8	
	Skewness		-.417	.464
	Kurtosis		-.667	.902

4.2.3. Post-Test Data for Experimental Group (EG):

4.2.3.1 Post-Test for Conceptual Understanding:

The descriptive statistics of posttest for conceptual understanding of the experimental group is listed below:

Table 13 Descriptive statistics of post-test for CU of EG

Descriptives

			Statistic	Std. Error
POSTTEST1	Mean		6.36	.270
	95% Confidence Interval for Mean	Lower Bound	5.80	
		Upper Bound	6.92	
	5% Trimmed Mean		6.33	
	Median		6.00	
	Variance		1.823	
	Std. Deviation		1.350	
	Minimum		4	
	Maximum		9	
	Range		5	
	Interquartile Range		2	
	Skewness		.378	.464
	Kurtosis		-.599	.902

4.2.3.2. Post-Test for Math Anxiety

The table below shows the descriptive statistics of post-test for Math anxiety of EG

Table 14 descriptive statistics of post-test for MA of EG

Descriptives

			Statistic	Std. Error
POSTANXIETY1	Mean		18.76	.946
	95% Confidence Interval for Mean	Lower Bound	16.81	
		Upper Bound	20.71	
	5% Trimmed Mean		18.68	
	Median		17.00	
	Variance		22.357	
	Std. Deviation		4.728	
	Minimum		12	
	Maximum		27	
	Range		15	
	Interquartile Range		8	
	Skewness		.266	.464
	Kurtosis		-1.278	.902

4.2.4. Post-Test Data for Control Group (CG)

4.2.4.1. Post-Test for Conceptual Understanding:

The table below shows the descriptive statistics of the post-test for CU of CG:

Table 15 Descriptive statistics of POST-TEST for CU of CG

Descriptives

			Statistic	Std. Error
POSTTEST2	Mean		4.64	.399
	95% Confidence Interval for Mean	Lower Bound	3.82	
		Upper Bound	5.46	
	5% Trimmed Mean		4.66	
	Median		5.00	
	Variance		3.990	
	Std. Deviation		1.997	
	Minimum		0	
	Maximum		9	
	Range		9	
	Interquartile Range		3	
	Skewness		-.071	.464
	Kurtosis		.721	.902

4.2.4.2. Post-Test for Math Anxiety:

Table 16 descriptive statistics of post-test MA for CG

Descriptives

			Statistic	Std. Error
POSTANXIETY2	Mean		23.08	.816
	95% Confidence Interval for Mean	Lower Bound	21.40	
		Upper Bound	24.76	
	5% Trimmed Mean		23.03	
	Median		23.00	
	Variance		16.660	
	Std. Deviation		4.082	
	Minimum		17	
	Maximum		30	
	Range		13	
	Interquartile Range		7	
	Skewness		.153	.464
	Kurtosis		-1.198	.902

4.3. Normality Test

The normality test checks the data set if it is modeled as a normality curve and to determine how likely it is for the primary variable of the data set to be normally distributed.

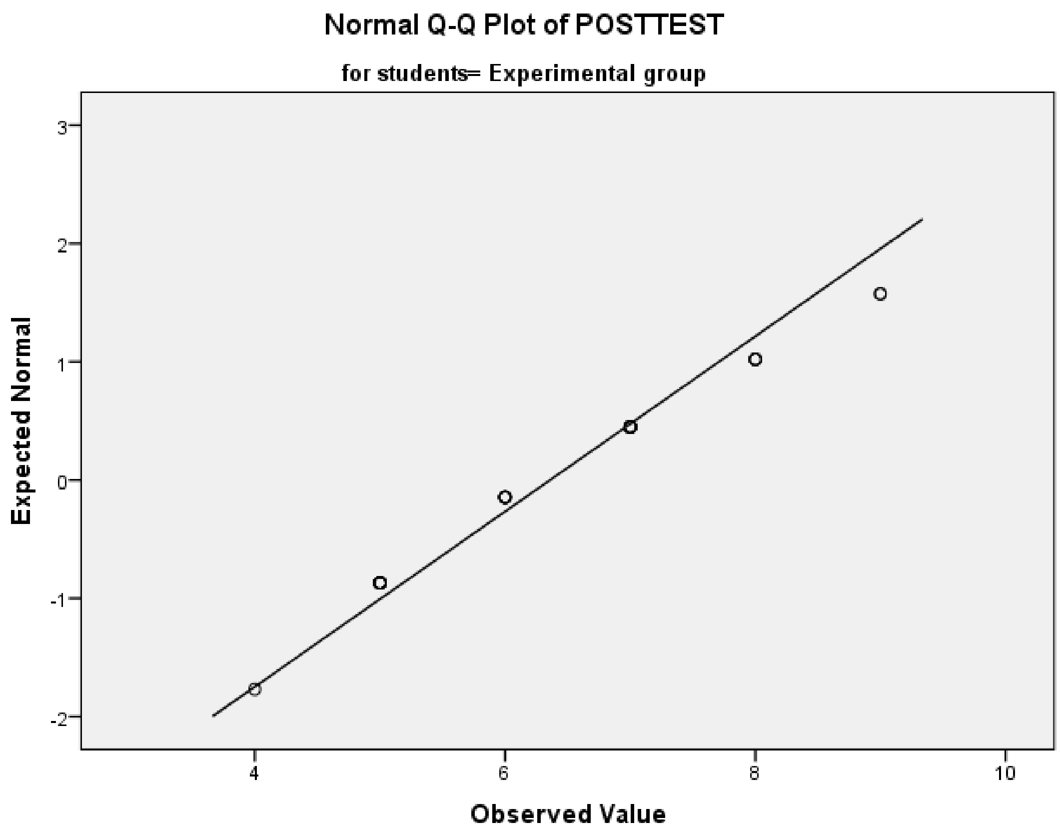
4.3.1. Shapiro Wilk Test

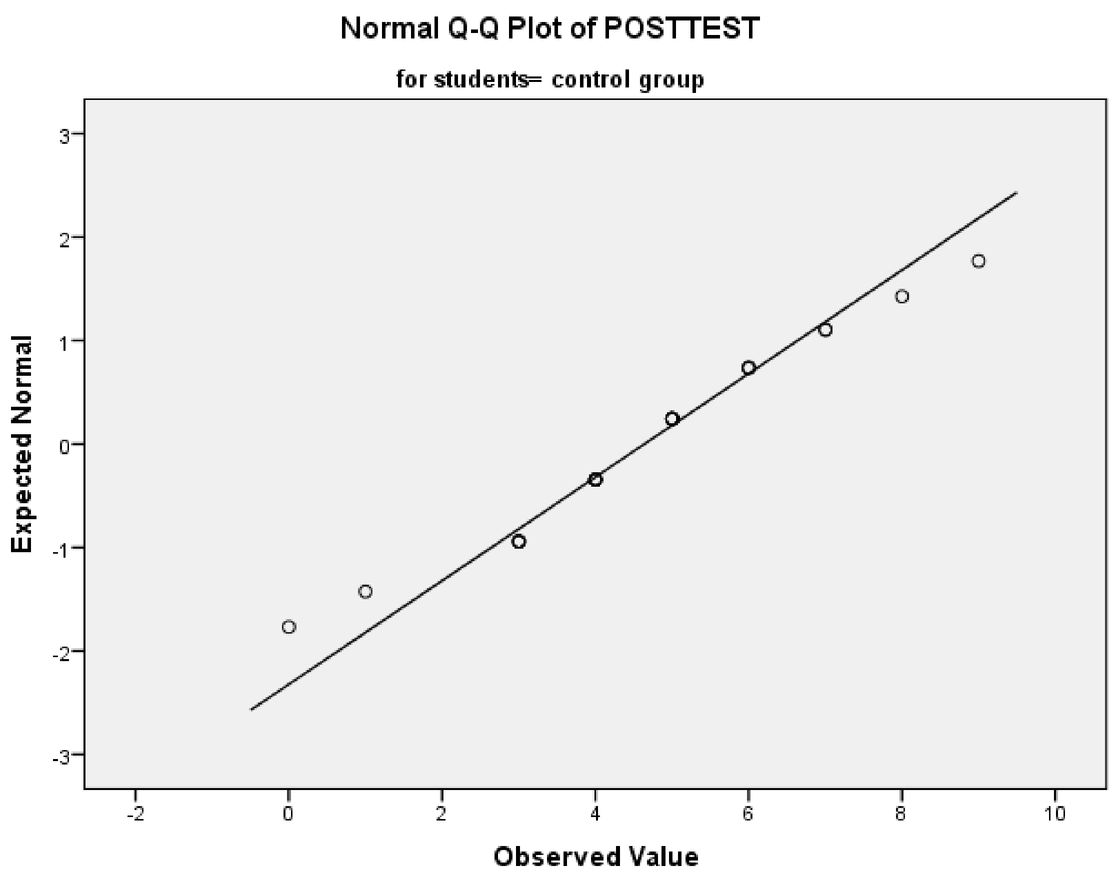
This test is specifically used to check the normal distribution of the data. With a data size ranging from 0 to 2000, it is the most powerful test to check the normality.

- The P-value of the test results >=0.05, the distribution is normal and the null hypothesis is not rejected.
- The P-value of the test results <=0.05, the distribution is not normal and the null hypothesis is rejected.

4.3.2. Normality Test for Pre and Post Test of Conceptual Understanding

The normal Q-Q plot of the experimental and control post-test scores of conceptual understanding is shown in the figures below:


Normal Q-Q Plot of POSTTEST
for students= Experimental group
Expected Normal
Observed Value
3
2
1
0
-1
-2
4
6
8
10


Normal Q-Q Plot of POSTTEST
for students= control group
Expected Normal
Observed Value
3
2
1
0
-1
-2
-3
-2
0
2
4
6
8
10

The above graphs show that the data points lie above or near the diagonal line. This shows that the data is normally distributed.

The results could be further confirmed from the hypothesis testing whether the data deviates from the normal distribution. The test of normality is shown below:

Table 17 Test of Normality for CU of Pre-test and post-test for EG and CG

Tests of Normality

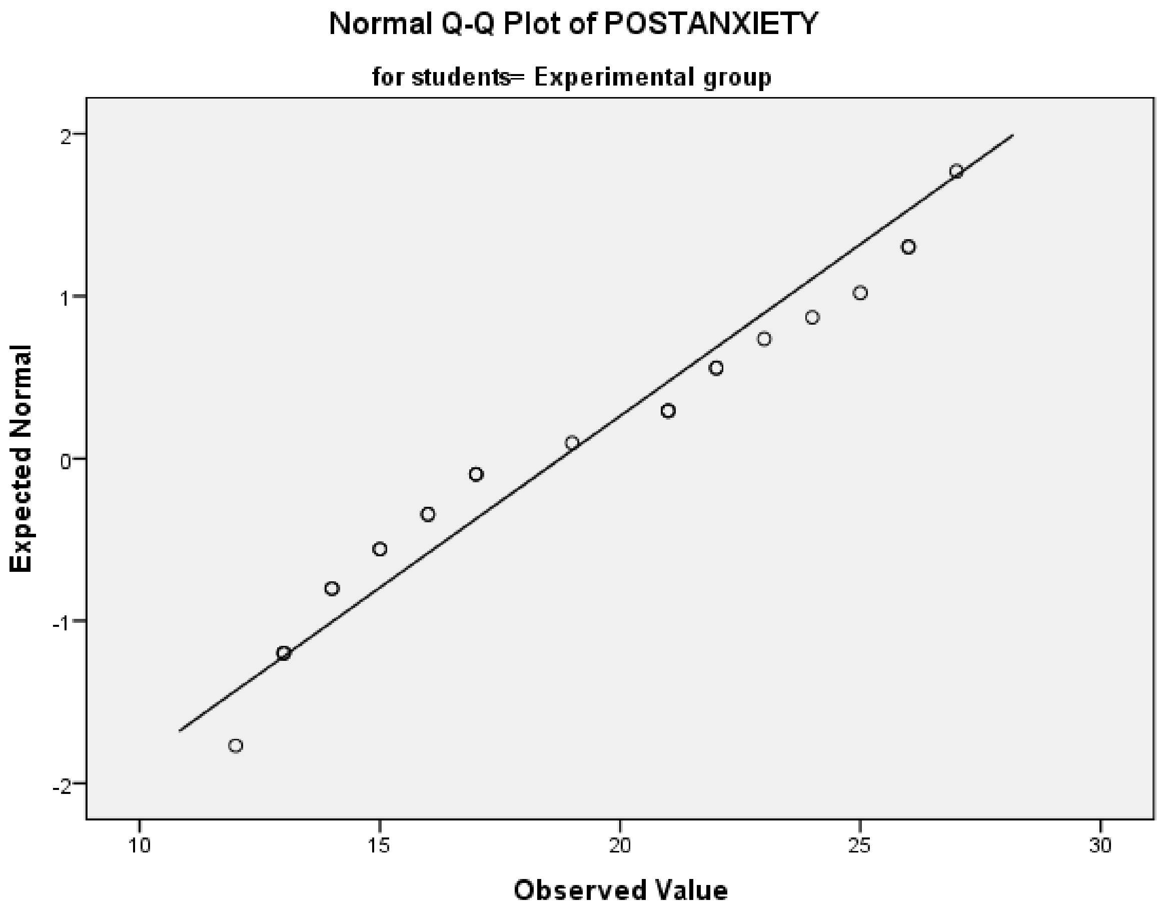
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	students	Statistic	df	Sig.	Statistic	df	Sig.
PRETEST	Experimental group	.156	25	.117	.946	25	.207
	control group	.133	25	.200*	.962	25	.446
POSTTEST	Experimental group	.165	25	.077	.927	25	.073
	control group	.148	25	.161	.964	25	.493

*. This is a lower bound of the true significance.

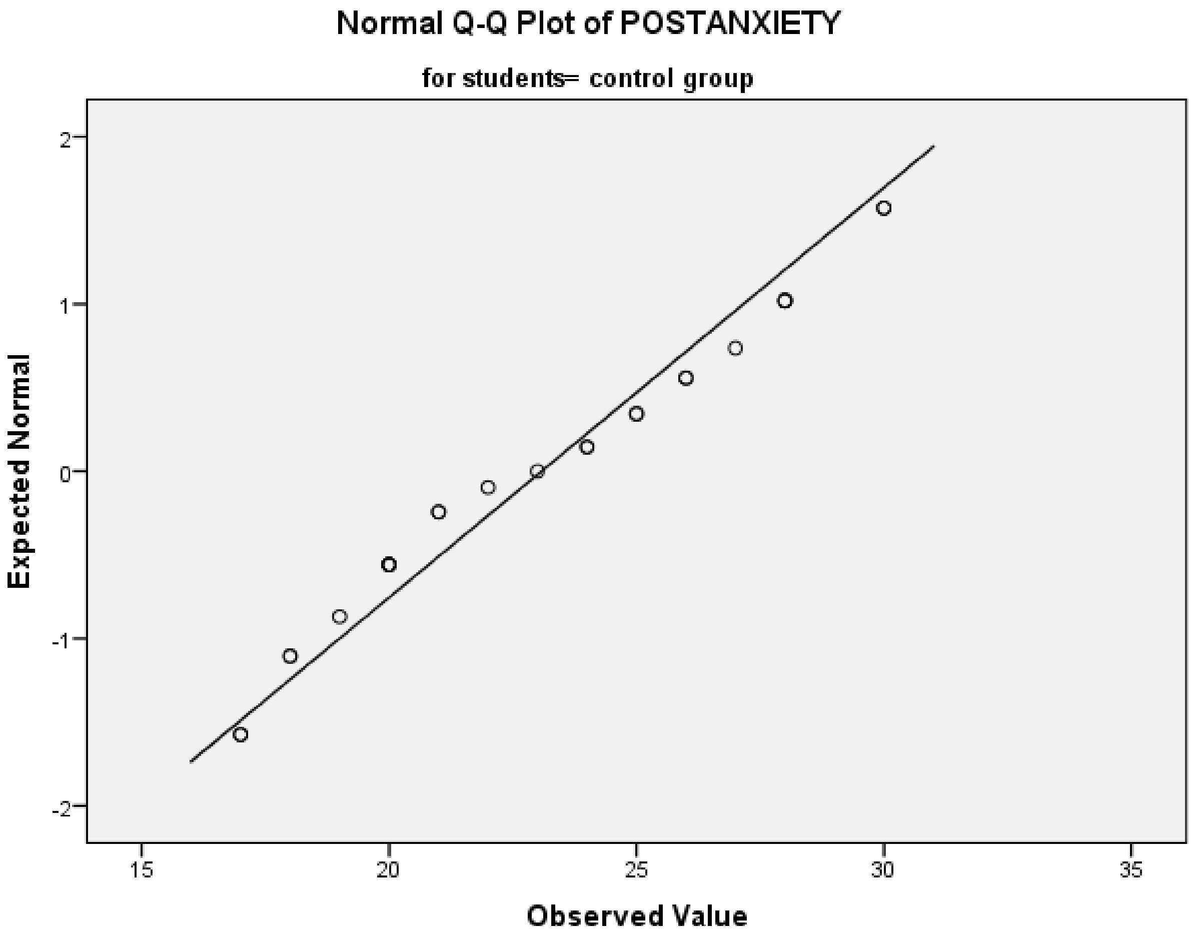
- The p-value for the experimental group post-test scores > 0.05. This indicates that the distribution is normal and the null hypothesis is not rejected
- The p-value for the control group post-test scores > 0.05. This shows that the distribution is normal and the null hypothesis is not rejected.

4.3.3. Normality Test for Pre and Post Math Anxiety

The normal Q-Q plot for the post Math anxiety of experimental and control group is shown below:



Normal Q-Q Plot of POSTANXIETY
for students= Experimental group
Expected Normal
Observed Value
2
1
0
-1
-2
10
15
20
25
30



From the above two graphs, we see that most of the points are close to the diagonal line or above the diagonal line. This confirms that the data is normally distributed.

The results could be further confirmed from the hypothesis testing whether the data deviates from the normal distribution. The test of normality is shown below:

Table 18 Test of Normality for MA of Pretest and Posttest of EG and CG

Tests of Normality

	students	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
PREANXIETY	Experimental group	.099	25	.200*	.975	25	.769
	control group	.110	25	.200*	.949	25	.237
POSTANXIETY	Experimental group	.165	25	.077	.929	25	.081
	control group	.135	25	.200*	.943	25	.176

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The p-value of the experimental group post-anxiety results is greater than 0.05 which confirms that the data is normally distributed. The p-value of the control group post-anxiety score is also greater than 0.05 which confirms again that the data is normally distributed and the null hypothesis is not rejected.

4.4. T-Test

The t-test is a type of inferential statistics that is used to check if there exists a difference in means of two groups of data. This test is used with the data set that follows a normal distribution and may have unknown variance. This test is used in the hypothesis testing where the **null-hypothesis states** that the two means are not significant i.e. they both are the same.

The following flowchart shows the correct t-test to be used according to the sample size and other characteristics of the sample:

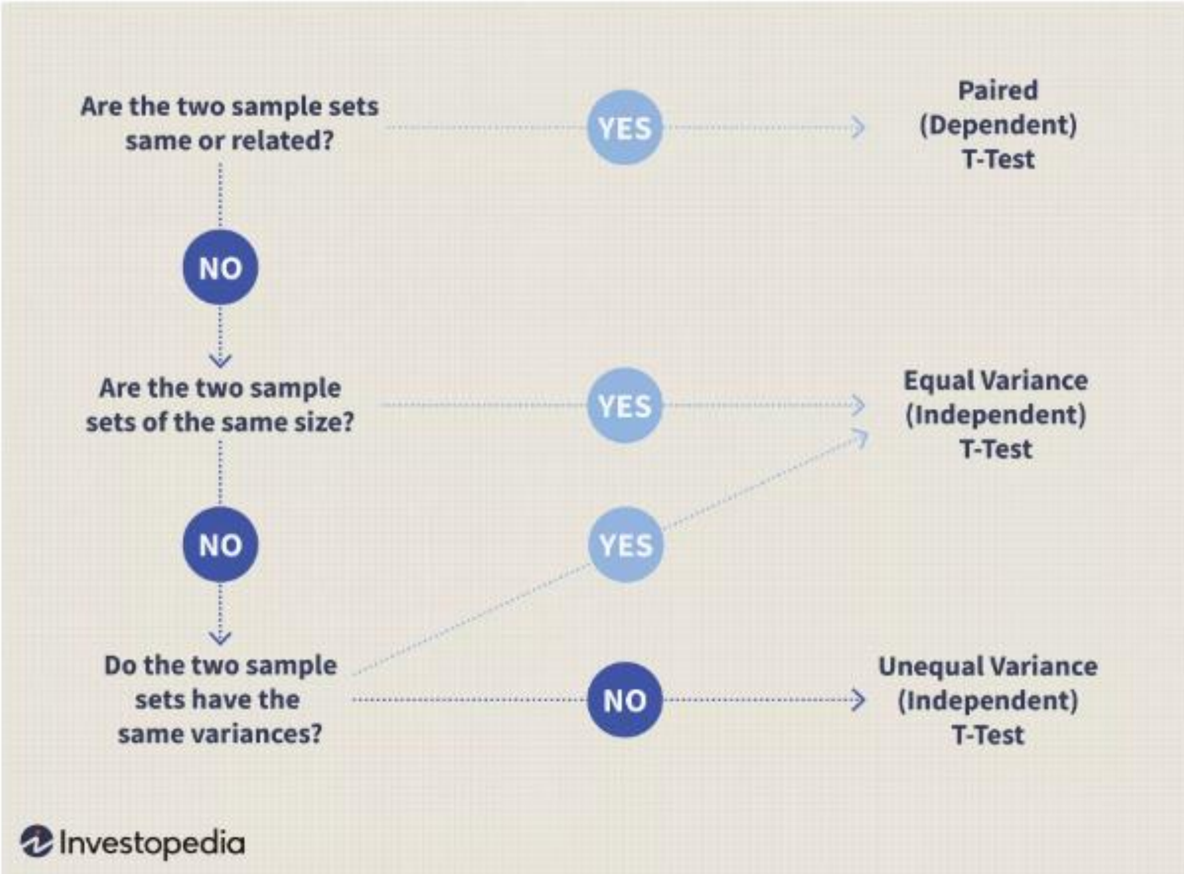


Image by Julie Bang © Investopedia 2019

Figure 5 Selection of T-Test

4.4.1. T-Test for the Pre and Post-test of Conceptual understanding of Experimental Group (EG) and Control Group (CG)

Table 19 T-Test for the CU of EG and CG

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PRETEST	Equal variances assumed	.074	**.787**	1.062	48	**.294**	.520	.490	-.464	1.504
	Equal variances not assumed			1.062	47.425	**.294**	.520	.490	-.465	1.505
POSTTEST	Equal variances assumed	1.585	**.214**	3.567	48	**.001**	1.720	.482	.750	2.690
	Equal variances not assumed			3.567	42.146	**.001**	1.720	.482	.747	2.693

From the Levene's test for equality of variance in the pre-test, we see that the p-value (sig) is greater than 0.05. This shows that the variance of both sets of data are equal (homogeneity of variance is not violated). For the post-test, the p-test value is greater than 0.05 which indicated equal variance of both sets of data (homogeneity of variance is shown).

To check the equality of means in the pre-test, the p-value (sig) of the t-test with equal variance assumed will be examined. The value is 0.233 that is greater than 0.05 and we can conclude that the null hypothesis is not rejected and the means are almost equal.

For checking the equality of means in the post-test, the p-value (sig) of the t-test with equal variance assumed will be examined. The value is 0.001 that is less than 0.05 and it is confirmed that the null hypothesis is rejected and the means of the conceptual understanding test of the experimental group and control group are not equal.

4.4.2. T-Test for the Pre and Post-test of Math Anxiety of Experimental Group (EG) and Control Group (CG)

Table 20 T-Test for MA of CG and EG

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PREANXIETY	Equal variances assumed	5.528	**.023**	-1.212	48	**.231**	-1.960	1.617	-5.212	1.292
	Equal variances not assumed			-1.212	40.368	**.233**	-1.960	1.617	-5.228	1.308
POSTANXIETY	Equal variances assumed	1.208	**.277**	-3.458	48	**.001**	-4.320	1.249	-6.832	-1.808
	Equal variances not assumed			-3.458	46.998	**.001**	-4.320	1.249	-6.833	-1.807

First of all, the p-value of the Levene's test for equality of variance is examined. The p-value (sig) of the pre-test is 0.023 which is lesser than 0.05 which tells that unequal variances are assumed for both sets of data.

The p-value of the post-test is 0.277 which is greater than 0.05. That confirms the equal variances of both the sets of data.

To check if both sets of data have equal means, the p-value of the t-test is examined. For the pre-test, the p-value of the t-test with unequal variance assumed is 0.233 > 0.05. That confirms that the means of the pre-anxiety score of the experimental group and control group is approximately the same.

For the post-test, the p-value of the t-test with equal variance assumed is 0.001 < 0.05. that shows that the mean of the EG and CG is not equal.

4.4.3 T-Test of the Pre-test Questions

Table 21 T-Test of the pre-test Questions

QUESTIONS	MEAN OF EXPERIMENTAL GROUP	MEAN OF CONTROL GROUP	SIGNIFICANCE
• Having to complete a worksheet by yourself.	2.80	3.32	0.111
• Thinking about a math's test the day before you take it.	2.88	3.08	0.557
• Watching the teacher work out a math problem on the board.	2.40	2.84	0.100
• Taking a math test.	2.64	3.08	0.255
• Being given math homework with lots of difficult questions that you have to hand in the next day.	3.28	3.68	0.157
• Listening to the teacher talk for a long time in math.	2.80	2.92	0.755
• Listening to another child in your class explain a math problem.	2.64	2.52	0.737
• Finding out that you are going to have a surprise math quiz when you start your math lesson.	2.96	3.36	0.199
• Starting a new topic in math.	1.76	1.44	0.236

The above table shows that the significance of all the questions is greater than 0.05. The significance greater than 0.05 shows that the null hypothesis is not rejected and the mean of all the mAMAS questions of the experimental group and control groups are almost the same.

Table 22 T-Test of the Post-test Questions

QUESTIONS	MEAN OF EXPERIMENTAL GROUP	MEAN OF CONTROL GROUP	SIGNIFICANCE
• Having to complete a worksheet by yourself.	2.24	2.93	0.023
• Thinking about a math's test the day before you take it.	2.36	2.92	0.039
• Watching the teacher work out a math problem on the board.	1.52	2.44	0.000
• Taking a math test.	2.28	3.00	0.019
• Being given math homework with lots of difficult questions that you have to hand in the next day.	2.48	3.16	0.017
• Listening to the teacher talk for a long time in math.	2.36	2.36	1.00
• Listening to another child in your class explain a math problem.	1.88	2.56	0.041
• Finding out that you are going to have a surprise math quiz when you start your math lesson.	2.36	2.40	0.890
• Starting a new topic in math.	1.32	1.24	0.663

The above table shows that the significance of most of the questions is less than 0.05. This leads to the rejection of the null hypothesis and concludes that the mean of the mAMAS questions of the experimental and control group is not the same and shows a significant difference.

From these results, it is quite clear that the post Math anxiety test of control and experimental group shows more anxiety among the control group students and comparatively less anxiety is observed among the treated students as compared to their pre anxiety score.

4.4.4. Correlation between Math performance and Math anxiety

The correlation between the math conceptual understanding scores and the math anxiety of EG is shown below**:**

Table 23 Correlation between Math Performance and Math Anxiety in post-test of EG

Correlations

		POSTTEST1	POSTANXIETY1
POSTTEST1	Pearson Correlation	1	-.554**
	Sig. (2-tailed)		.004
	N	25	25
POSTANXIETY1	Pearson Correlation	-.554**	1
	Sig. (2-tailed)	.004	
	N	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation between the post-test and the post-anxiety of EG is -0.554. The negative relation shows that the increase in one variable causes a decrease in the other.

The correlation between the math conceptual understanding scores and the math anxiety of CG is shown below**:**

Table 24 correlation in post-test of Math performance and Math Anxiety of CG

Correlations

		POSTTEST2	POSTANXIETY2
POSTTEST2	Pearson Correlation	1	-.472*
	Sig. (2-tailed)		.017
	N	25	25
POSTANXIETY2	Pearson Correlation	-.472*	1
	Sig. (2-tailed)	.017	
	N	25	25

*. Correlation is significant at the 0.05 level (2-tailed).

The correlation between Post-CU and Post-MA of CG is -0.472. The negative correlation between the post-test and post-anxiety shows with the increase in the one variable causes a decrease in the other variable.

4.5. Cronbach's Alpha

Cronbach's Alpha measures internal consistency between items on a scale.

The Cronbach's Alpha to check the reliability of the 9 items scale of Math Anxiety test (mAMAS) was found by using SPSS and its results are as follow:

Table 25 Cronbach's Alpha for Pre-Anxiety

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.727	.726	9

Table 26 Cronbach's Alpha for Post-Anxiety

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.691	.680	9

The Cronbach's Alpha of 0.70 and above is considered as good and acceptable in most of the cases. Whereas in most social science research studies, it is found that in the alpha value is often below 0.70 when the primary class's student's behavior is measured (Erdley, Cain, Loomis, Dumas-Hines, & Dweck, 1997). This frequent change in the value of Cronbach's alpha in the case of the primary level Math Anxiety scale test might be due to the fact that Cronbach's Alpha is sensitive to the number of items in the scale. In the primary grade tests, the number of items is kept smaller keeping in consideration the capacity of students as compared to the elementary grades students.

The Cronbach's alpha value of pre-anxiety test of EG and CG is 0.727 and for the post-anxiety test it is 0.691. This shows that the mAMAS test is quite reliable to check Math Anxiety among primary grade students.

5. Discussion

Pakistan is facing a lot of issues in the education system that leads to a low literacy rate and high dropout rate. One of the biggest issues that the country is facing is the outdated teaching methods are failing to develop skills in students that the present challenges of society require (Zafar & Ali, 2018). The world is progressing at a very high pace and if the students of the country do not have the conceptual understanding and are wasting their time and energy in the rote learning of the book content, there will be no innovation and progress in the country. UNESCO rates in Pakistan are at a lower Education for All (EFA) development index because of many education sector problems that the country is facing such as gender discrimination, low enrolment in the primary class, adult literacy, and poor quality of education (Rashid & Mukhtar, 2012). To improve the quality of education, the teaching methodologies should be updated that could involve more students with different backgrounds, prior knowledge, experience, and learning styles.

This study focuses on the math classroom. One section of Class fourth students was assigned as the experimental group and the other section of the class fourth was a control group. In the pre-test of conceptual understanding, the experimental group and control group performed almost equally with an average of 3.76 and 3.08 respectively. Such a low average shows a lack of conceptual understanding of the students. This situation was shocking as the basic concepts of students were really weak when it came to applying them in different real-life scenarios. The teaching methodology was changed from the traditional ways and the Universal Design of

Learning (UDL) classroom was being introduced in the experimental group only while the control group was still taught from the traditional teaching methods. With the help of UDL guidelines and CAST UDL Lesson builder, the lesson plans for everyday lessons were being designed. The learning style of every individual is different. Learning styles describe the preferences of an individual by which they can learn more efficiently and knowing the preferred learning style of students would act as a catalyst for instructors to regulate and design their learning strategies (Fleming & Baume, 2006). For the purpose of knowing the students preferred learning style, students of the experimental group were given a VAK test because it was the only group on which the treatment was going to be applied (Appendix A). A test of conceptual understanding was designed by the researcher that was based on the concepts of multiplication, division, and fractions that the students took before the intervention started (Appendix B). The intervention was of a 3 weeks' time period. Students took a keen interest in the education games based on the concepts they were supposed to learn. As children love to play, so it was making sure they learn new things through the activities and games without even realizing and taking the burden of it that was contextualized as well. They worked in groups to solve different problems with the scaffolding provided by the instructor. Also, the groups watched the related videos on a laptop. They had competitions among different groups of students to make them feel challenged. The level of difficulty is upgraded every day. Every day the lesson starts with a brief explanation of the topic by the instructor to the students. This made them aware of the goal of the class activities and what they should learn by the end of the period. A similar test of the conceptual understanding was conducted as a posttest by the end of the intervention period. To check the difference in the performance of the students. A visible difference in the performance of the EG students was observed with an average of 3.76 shifted to 6.12 whereas the score shifted from

3.08 to 4.64 for the control group. Around 90% of the students in the EG showed improvement in the results scores of the posttest. The improvement in the results was the result of the teaching Methodology that involved all students despite their learning styles. They knew what their learning aims were and they felt challenged that motivated them to work towards their goals. This intervention results showed that by changing the teaching methodology and making it more student-centered with the appropriate amount of scaffolding provided when required, the students will have a conceptual understanding instead of rote memorization. The concepts were shown from so many different ways that every child learned in the classroom from their own learning preferences.

Math anxiety is one of the hindrances in math achievements. Psychologists think that Math anxiety has a negative impact on math performance as it decreases the cognitive resource called the working memory. The psychologist suggests that working memory capacity and math anxiety are the factors on which the math performance depends (Daneshamooz, Alamolhodaei, & Darvishian , 2012). Problem-solving in math requires a good working memory and with the math anxiety taking over most of the capacity of working memory, the performance in math gets affected. Math anxiety is one of the reasons that some students who are even good in math perform poorly during tests. In this research, the results show that by changing the teaching methodology math anxiety could be reduced that will result in the better performance of students. The instructor used the UDL guidelines to help students learn the basic concepts of multiplication, division, and fractions. Students of all learning styles had a variety of options in the class to learn the concepts, unlike the traditional teaching methodology. The students worked in groups to solve math questions, they played games that increased their problem-solving skills and they felt challenged. With an open learning environment, students had room for error so they can learn out of it by discussing it with their peers and instructor. The correlation between post-test and post-anxiety calculated came out to be negative. The negative correlation of EG is -0.557 whereas the correlation of the CG is -0.472. The negative sign shows that with the increase in the post-test marks, Math anxiety is decreased. The more the number is closer to -1, the greater the negative correlation between the two variables. This means that the EG shows a stronger negative correlation as compared to the CG. The t-test of pre-anxiety shows a p -value>0.05, which shows no significant difference in the mean of EG and CG. The post-anxiety shows p-value<0.05 which is proof of the significant difference in the mean values of EG and CG. The UDL classroom had a positive impact on math-anxiety. It made them more confident in their math skills and they were ready to participate in the problems that required mathematical solutions.

5.1. Limitations

UDL classroom was being introduced in the EG. There were a few limitations in the study that follows:

- There was only one instructor in the classroom. For the scaffolding of 25 students, it was better to have more than one instructor in the class.
- Only multiplication, division, and fractions were covered in the class due to time constraints. With more topics covered in more time periods, better conclusions could be deduced about the impact of UDL guidelines on the students.
- The time period of each class was only 30 minutes that was very short to complete certain activities. With a flexible time slot, students could complete the activities with more precision.
- Only class fourth was involved in the research. With more primary classes as study participants, more accurate results could be concluded.

6. Conclusion

6.1. Conclusion of Research Question 1

The research was conducted on the implementation of UDL in primary class with very less or no use of technology. The purpose of this research was to check the effectiveness of the UDL classroom on the conceptual understanding of the students. The purpose of undertaking this area of study was the inadequacy of research already being conducted on the implementation of UDL guidelines on primary students and it impacts the concept formation.

Math is an abstract subject that needs more imagination for a clearer picture of the ideas being taught. Every class consists of students with different needs to grasp a concept because of the different learning preferences each one of them has. To benefit all of them, the instructor used UDL guidelines to create lesson plans that could engage everyone in the class either they are visual, kinesthetic, or auditory learners. They were shown visuals i.e. colorful images, videos, tables, and graphs. The font sizes and color contracts were made visible enough to catch the attention and the important information was highlighted. The instructor activated the prior knowledge of the students by having an oral discussion with them about what they already know and the instructor kept repeating the bullet points of what is the prerequisite of understanding the new topic. One class was being utilized just for the purpose of activating prior knowledge as it is the base on which the new concepts will be built. The group work helped the students to coordinate with each other and find solutions to the problems being given. They discussed it among the peers and this helped them to learn teamwork as well. The students were given the autonomy to express their learning in whatever way they feel comfortable.

The pretest-posttest design quasi-experimental research was conducted to see the effects of UDL on the student's performance in Math. The experimental group and the control group had 25 number of students. The same pretest was conducted in both groups. The treatment was given to the EG only while the CG was taught with the traditional methods. The posttest showed a difference in the performance in the performance of both groups where the EG showed better results as compared to the CG. This made it clear that the UDL instructions worked better on students than the traditional classroom methodologies.

These results proved that the null hypothesis is rejected that said there is no significant difference in the posttest scores of the EG and CG and the alternative hypothesis is failed to reject. This concluded that the UDL classroom increased the conceptual understanding of primary class students in math.

6.2. Conclusion of Research Question 2

In order to examine the math anxiety of students in the traditional classroom and the variation in it after the UDL classroom, mAMAS test was conducted on students before and after the implementation of UDL principles in the classroom. Immense research is already being conducted on the math anxiety of students and it impacts the students' achievement but there is a lack of research on the correlation of math anxiety and the conceptual understanding of students after the UDL implemented in the classroom.

It has been stated in the previous researches that by altering the teaching methodologies, the correlation in math performance and math anxiety could be negative and students can overcome math anxiety and show improved results. After applying UDL principles in the classroom, students had multiple means of action, multiple means of expression, and multiple means of engagement. This autonomy lets the students learn with their own pace and preferred learning style. Also, the students could relate the math concepts with their everyday life and found it interesting and useful. These changes in their classroom environment caused a positive effect on them and their math anxiety showed a significant decrease in score in the posttest that was taken after the interventions. The correlation in post math anxiety score and the conceptual understanding came out to be negative. The negative correlation is a good sign as it tells that the decrease in anxiety acts as a foundation for the improved results of the conceptual understanding.

7. Recommendation

Studies show that very limited work is being done in the area of UDL, specifically in Pakistan. There is vast room for checking the effectiveness of the implementation of UDL on students. This research specifically focused on students with different learning styles. There are students with special educational needs as they face learning disabilities. A lot of research is conducted on the types of learning disabilities, emotional disabilities, Autism spectrum disorders, Lack of appropriate background knowledge, etc. that students might face and that is a hindrance in their learning and how the UDL guidelines could help the students overcome the special needs and perform better, but the implementation of the principles on the students with these problems need to be worked on to check the level of improvement it brings along in the conceptual understanding of students.

7.1. Working Memory Effects

The research already found the negative correlation between math anxiety and math performance. But, there is one more factor, working memory capacity (WMC), which could affect the math performance. Daneshamooz, Alamolhodaei, & Darvishian (2012) showed that there is a positive correlation in WMC and math performance when the learning method was the e-learning method, cooperative learning method, and traditional classroom environment. WMC is one of the major factors that could affect the conceptual understanding of math in students.

Both, the WMC and the Math anxiety, have an interactive effect on the math performance (Daneshamooz, Alamolhodaei, & Darvishian , 2012) .Further research could be conducted on how the UDL classroom affects the working memory and eventually the math performance and is there a correlation between working memory and math anxiety with the UDL principles are applied in the classroom.

7.2. UDL Could be implemented with Low-Technology

When there is a lot of research and work being done in developed countries, there are some underdeveloped nations that are still struggling to make their learning ways up-to-the-mark so their future generation could be productive for the world and for their own nation. It is the expense of the latest technologies that are hard for developing countries to bear. There is a gap in the implementation of technology in developing and developed countries. The problem does not just lie in the use of technology but in the teacher’s training as well (Hamidi, Ghorbandordinejad, Rezaee , & Jafari , 2011). This research shows that it's not just the technology that makes it possible to follow the UDL guidelines. It could bring positive outcomes with pedagogy, learning styles, providing the appropriate support that a student requires, and by using the basic technologies.

7.3. Make Learning More Active

By engaging students in what they are learning by using the UDL guidelines, it will become easy, fun, and meaningful. Students will not just limit their leaning in the classroom, but they will be keen to apply their learning in the real world too and will become a lifelong learner. For the development of critical thinking, problem-solving, and effective learning among students at an early age, the instructors need to move from the traditional classroom to active learning. For this purpose, the curriculum needs to focus more on the quality and student engagement rather than quantity of the content being taught.

7.4. Future work

1. Further research could be conducted on the impact of UDL on students with learning disabilities, emotional disabilities, Autism spectrum disorders, Lack of appropriate background knowledge.
2. More research needed on how the UDL classroom affects the working memory and eventually the math performance of students.
3. Not much work is done on the correlation between working memory and Math anxiety when the UDL principles are applied in the classroom. This research could be carried out in the future work of UDL.

References

Bibliography

Ailaan, A. (2017). *Why are Pakistani students deplorable at Math and science* . Dawn.

Akkoyunlu, B., & Soylu, M. Y. (2008). A Study of Student's Perceptions in a Blended Learning Environment Based on Different L earning Styles. *Educational Technology & Society*.

Al-Azawei, A., Serenelli, F., & Lundqvist, K. (2016). Universal Design for Learning (UDL): A Content Analysis of Peer-Reviewed Journal Papers from 2012 to 2015. *The Scholarship of Teaching and Learning,* .

Apipah, S., Kartono, & Isnarto. (2017). An analysis of mathematical connection ability based on student learning style on visualization auditory kinesthetic (VAK) learning model with self-assessment. *Journal of Physics: Conf. Series 983*.

Ashcraft, M. H. (2002). Math Anxiety: Personal, Educational, and cognitive consequences . *Directions in psychological Science, 11, 181–185.*

Bennett, C. (2015). Individual Differences and How Teachers Perceive Them. *The Social Studies*.

Boaler, J. (2009). Paying the Price for "Sugar and Spice": Shifting the Analytical Lens in Equity Research. *Mathematical thinking and Learning Volume 4, 2002 - Issue 2-3*.

Carey, E., Hill, F., Devine, A., & Szucs, D. (2017). The Modified Abbreviated Math Anxiety Scale: A Valid and Reliable instrument for use with children. *frontiers in Psychology*.

CAST. (2018). UDL and the learning brain.

Costin, C. (2017). *What is the role of teachers in preparing future generations?*

Courey, S. J., Tappe, P., Siker, J., & LePage, P. (2012). Improved Lesson Planning With Universal Design for Learning (UDL). *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children* .

Daneshamooz, S., Alamolhodaei, H., & Darvishian , S. (2012). Experimental Research about Effect of Mathematics Anxiety, Working Memory Capacity on Students' Mathematical Performance With Three Different Types of Learning Methods . *ARPN Journal of Science and Technology VOL 2*.

Eisenberg, N., Fabes, R., Schaller, M., Miller, P., Carlo, G., Poulin, R., . . . Shell, R. (1991). Personality and Socialization Correlates of Vicarious Emotional Responding. *Journal of Personality and Social Psychology*.

Erdley, C., Cain, K., Loomis, C., Dumas-Hines, F., & Dweck, C. (1997). The relations among children's social goals, implicit personality theories and response to social failure. *Developmental Psychology, 33, 263–272.* .

Ertmer, P. A. (1999). Addressing First- and Second-Order Barriers to Change: Strategies for Technology Integration .

Finlayson, M. (2014). Addressing math anxiety in the classroom. *Improving Schools 2014 17: 99*.

Fleming, N., & Baume, D. (2006). Learning Styles Again: VARKing up the right tree! . *Educational Developments, SEDA Ltd, Issue 7.4, Nov. 2006, p4-7.* .

Freire, P. (1970). *Pedagogy of the Oppressed .*

Gholami, S., & Bagheri, M. (2013). Relationship between VAK Learning Styles and problem solving styles regarding gender and students' field of study. *Journal of Language Teaching and Research, Vol. 4, No. 4, pp. 700-706*.

Hall, T., Strangman, N., & Meyer, A. (2003). Differentiated instruction and implications for UDL implementation.

Hamidi, F., Ghorbandordinejad, F., Rezaee , M., & Jafari , M. (2011). A Comparison of the Use of Educational Technology in the Developed/Developing Countries. *Procedia Computer Science* .

Haris, K. R., & Graham, S. (2012). *Universal design for learning in the classroom.* The Guilford Press.

Hopko, D. R., Mahadevan, R., Bare, R., & Hunt, M. (2003). The Abbreviated Math Anxiety Scale (AMAS): Construction, validity, and reliability. *Assessment, 10(2), 178–182. https://doi.org/10.1177/1073191103010002008*.

Hopko, D. R., McNeil, D., Lejuez, C., Ashcraft, M., Eifert, G., & Riel, J. (2003). The effects of anxious responding on mental arithmetic and lexical decision task performance. *Journal of Anxiety Disorders 17(6), 647–665.*

Hunt, J. H., & Andreasen, J. (2011). Making the mosts of Universal Design for Learning. *Mathematics Teaching in the Middle School , Vol. 17, No. 3*.

Izzo, M. V. (2012). Universal Design for Learning: Enhancing Achievement of Students with Disabilities .

Jackson, C. D., & Leffingwell, R. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *Mathematics Teacher, 92(7), 583–586.*

James, W. B., & Blank, W. (1993). Review and critique of available learning-style instruments for adults. *In D. Flannery (Ed.), Applying cognitive learning styles (pp. 47-58)*.

Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding It Up: Helping Children Learn Mathematics .* The National Academies Press.

King-Sears, M. (2009). Universal design for learning: technology and pedgogy. *Learning Disability Quarterly* .

Kinsella, K. (1995). Understanding and empowering diverse learners in ESL classrooms. In J. M. Reid (Ed.). *Learning styles in the ESL/EFL classroom (170-194)*.

Kurtts, S. A. (2006). Universal Design for Learning in Inclusive Classrooms. *Electronic Journal for Inclusive Education, 1 (10).*

Page, M. (2014). Technology-Enriched Classrooms: Effects on Students of Low Socioeconomic Status . *Journal of Research on Technology in Education* .

Posamentier, A. S., Smith, B., & Stepelman, J. (2010). *Teaching Secondary Mathematics: Techniques and Enrichment Units (8th ed.).* Toronto: Pearson Education.

Ramirez, G., Gunderson, E., Levine, S., & Beilock, S. (2012). Math Anxiety, Working Memory, and Math Achievement in Early Elementary School. *Journal of Cognition and Development Volume 14, 2013 - Issue 2*.

Rashid, D., & Mukhtar, S. (2012). Education in Pakistan: Problems and their Solutions. *International Journal of Academic Research in Business and Social Sciences November 2012, Vol. 2, No. 11*.

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal Design for Learning.*

Sheng, Y., & Sheng, Z. (2012). Is coefficient alpha robust to non-normal data? *Front. Psychol., 15 February 2012 | https://doi.org/10.3389/fpsyg.2012.00034*.

Sife, A. S., Lwoga , E., & Sanga, C. (2007). New technologies for teaching and learning: Challenges for higher learning institutions in developing countries. *International Journal of Education and Development using Information and Communication Technology*.

Soloway, E., Lochhead, J., & Clement, J. (1982). *Does computer programming enhance problem solving ability? Some positive evidence on algebra word problems.* New York: Academic Press.

Soloway, E., Lochhead, J., & Clement, J. (1982). DOES COMPUTER PROGRAMMING ENHANCE PROBLEM SOLVING ABILITY? SOME POSITIVE EVIDENCE ON ALGEBRA WORD PROBLEMS. *Computer Literacy (pp. 171–201). Academic Press.*

Szczygieł, M. (2019). How to measure math anxiety in young children? Psychometric properties of the modified Abbreviated Math Anxiety Scale for Elementary Children (mAMAS-E). *Polish Psychological Bulletin 2019, vol. 50(4) 303–315 DOI - 10.24425/ppb.2019.131003*.

(2017). *Technology in the UDL Classroom.* British Columbia.

Thomas, G., & Dowker, A. (2000). Mathematics anxiety and related factors in young children. *British Psychological Society Developmental Section Conference (Bristol).* .

TRUCANO, M. (2019, January 28). *A new research hub on the use of technology in education in developing countries*. Retrieved from worldbank.org.

UNESCO. (2007). *The Education system in pakistan: Assessment of the National Education Census.* Islamabad.

Vygotsky, L. (1978). *Mind in society.* Cambridge: Harvard University Press.

Wood, G., Pinheiro-Chagas, P., Júlio-Costa, A., Micheli, L., Krinzinger, H., Kaufmann, L., . . . Haase, V. (2000). Math Anxiety Questionnaire: Similar Latent Structure in Brazilian and German School Children. *Child Development Research DOI: 10.1155/2012/610192 Sep 16, 2014*.

Wren, D. G., & Benson, J. (2004). Measuring test anxiety in children: Scale development and internal construct validation. *Anxiety, Stress and coping An international Journal Volume 17, 2004 - Issue 3*.

Xhaferri, R., & Iqbal, K. (2010). *Unlocking the doors to opportunity.* Dawn.

Yang, Y., & Green, S. (2011). Coefficient Alpha: A Reliability Coefficient for the 21st Century? *Journal of Psychoeducational Assessment*.

Zumbo, B., & Rupp, A. (2004). Responsible modeling of measurement data for appropriate inferences: Important advances in reliability and validity theory. *The SAGE handbook of quantitative methodology for the social sciences (pp. 73–92). Thousand Oaks, CA: Sage Press.*

Zumbo, B., Gadermann, A., & Zeisser, C. (2007). Ordinal versions of coefficients alpha and theta for Likert rating scales. *Journal of Modern Applied Statistical Methods, 6, 21–29.*

Appendices

Appendix A

Conceptual understanding Pre and Post-Test (MULTIPLICATION, DIVISION, FRACTION)

Q1. The farmer's market opens for $2\frac{1}{5}$ hours in the morning and $3\frac{2}{5}$ hours in the afternoon. How long is the farmer's market open in a day?

A. $\frac{88}{15}$ $B.$ $\frac{28}{5}$ $C.$ $\frac{3}{15}$ $D.$ $\frac{15}{5}$

Q2. Ms. Ayesha had $4\frac{7}{12}$ boxes of pencils but $2\frac{1}{12}$ boxes of the pencils was broken. After she threw out the broken pencils, how many boxes of pencils were left?

A. $\frac{4}{12}$ $B.$ $\frac{7}{12}$ $C.$ $\frac{14}{7}$ $D.$ $\frac{30}{12}$

Q3. Aiman had $\frac{1}{5}$ of 100 rupees. Laiba had $\frac{1}{4}$ of 80 rupees. Who had more money?

A. Both had equal money. B. Laiba.
C. Aiman.

Q4. Rida is allowed to play video games for $\frac{5}{3}$ hours each day. She has already played for $\frac{4}{3}$ hours today.

What fraction of an hour does Rida have left to play video games today?

A. $\frac{1}{3}$ $B.$ $\frac{3}{4}$ $C.$ $\frac{1}{2}$ $D.$ $\frac{1}{4}$

Q5. There is a big forest in Africa. Each row in a forest has 37 trees and there are 985 such rows. How many total trees will be there altogether?

Answer:

A. 36445 B. 36554 C. 36545 D. 35445

Q6. A bicycle costs 3715 rupees. How much will be paid for 87 such bicycles?

A. 323,205 B. 362,204 C. 330,210 D.
345,876

Q7. There are 6 ovens in a pizza shop. A boy orders 240 pizzas. One of the oven got broken. How many pizzas should each oven make now? Each oven makes equal number of pizzas.

A. 50 B. 49 C. 48 D.
47

Q8. Each oven bakes 304 slices of pizzas. If each pizza have 8 slices, how many pizzas does the oven bakes?

A. 40 B. 38 C. 12 D. 14

Q9. Ayesha has 1546 boxes and each box has 34 chocolates. How many total chocolates does Ayesha has?

A. 42,564 B. 52,564 C. 62,564 D.
73,456

Q10. A playschool is taking the kids to the trip. For the safety of the kids, one teacher is responsible for a group of 15 kids. If there are 270 kids, how many teachers will go with them?

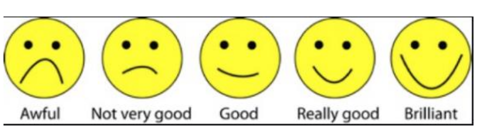
A. 20 B. 18 C. 16 D. 10

Appendix B

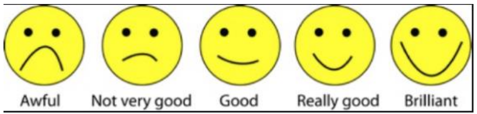
The modified Abbreviated Math Anxiety Scale (mAMAS)

- Circle how you feel when you encounter the following situations.

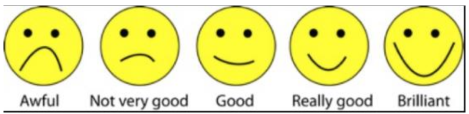
1. Having to complete a worksheet by yourself.



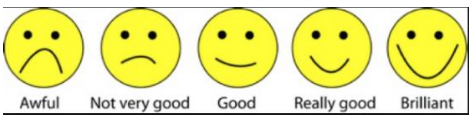
2. Thinking about a math's test the day before you take it.



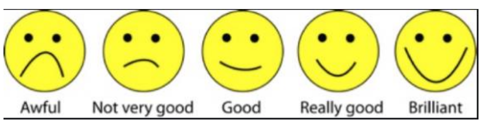
3. Watching the teacher work out a math problem on the board.



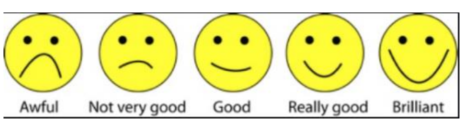
4. Taking a math test.



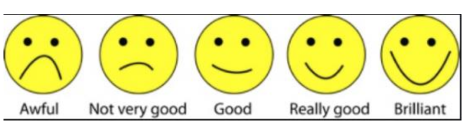
5. Being given math homework with lots of difficult questions that you have to hand in the next day.



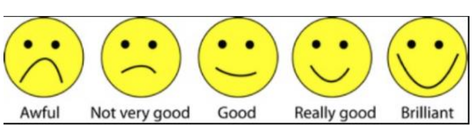
6. Listening to the teacher talk for a long time in math.



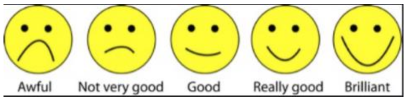
7. Listening to another child in your class explain a math problem.



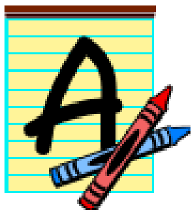
8. Finding out that you are going to have a surprise math quiz when you start your math lesson.



9. Starting a new topic in math.

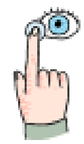


Appendix C



How Do I Learn?

Place a check (✓) in all the blanks that describe you. The list with the greatest number of checks is how you like to learn best.



Visual Learning Style

______ 1. I remember best by writing things down or drawing pictures.

______ 2. I ask for directions to be repeated.

______ 3. I like to read about something rather than hear about it.

______ 4. I am a good speller.

______ 5. I like to learn with posters, videos, and pictures.

______ 6. I am good at reading maps and graphs.

______ 7. When someone is talking, I create pictures in my mind about what they are saying.

______ 8. After school, I like to read books.

______ 9. I like it when my teacher uses lots of pictures when teaching.

______ 10. I can remember something if I picture it in my head.

______ **How many checks (✓) did you have?**

Remember to place a check (✓) in all the blanks that describe you.

Auditory Learning Style

_____ 1. I remember best if I hear something.

_____ 2. It is easier for me to listen to a story on tape than to read it.

_____ 3. I understand better when I read out loud.

_____ 4. I follow spoken directions well.

_____ 5. I like to sing or hum to myself.

_____ 6. I like to talk to my friends or family.

_____ 7. Music helps me learn things better.

_____ 8. I can easily remember what people say.

_____ 9. It helps when the teacher explains posters or pictures to me.

_____ 10. I can remember more about something new if I can talk about it.

_____ **How many checks (✓) did you have?**

Remember to place a check (✓) in all the blanks that describe you.

Tactile/Kinesthetic Learning Style

_____ 1. I remember best if I can make something that tells about what I am learning.

_____ 2. I would rather play sports than read.

_____ 3. I like playing card or board games to learn new things.

_____ 4. I like to write letters or write in a journal.

_____ 5. I like it when teachers let me practice something with an activity.

_____ 6. I like putting together puzzles.

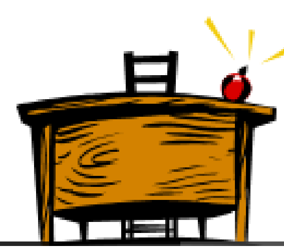
_____ 7. If I have to solve a problem, it helps me to move while I think.

_____ 8. It is hard for me to sit for a long time.

_____ 9. I enjoy dancing or moving to music.

_____ 10. I like to act things out to show what I have learned.

_____ **How many checks (✓) did you have?**



Tell Me . . .

Which list had the most (✓) checks? ________________

Which list had the fewest (✓) checks? ________________

Did you have any lists that had the same number of (✓) checks? ________________

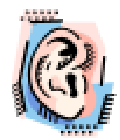
If so, which ones? ________________

Do you think the list that had the most checks (✓) tells how you like to learn best? ________________

What Does It Mean?

Visual Learning Style

- Pictures help you learn.
- Seeing things helps you organize your thoughts and remember things.
- You think in images or pictures.



Auditory Learning Style

- It helps for you to talk out loud.
- Sound and music help you learn.
- You learn best when you hear things more than once.

Tactile/Kinesthetic Learning Style

- It helps you to use your body, hands and sense of touch to learn new things.
- Writing, drawing and movement help you remember important things.
- You like to show what you have learned by demonstrating or making projects.