Supporting conceptual understanding of fifth-grade mathematics students by integrating STEAM intensive activities in teaching area, perimeter and information handling

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Approval

It is certified that the contents and form of the thesis entitled “Supporting conceptual understanding of fifth-grade mathematics students by integrating STEAM intensive activities in teaching area, perimeter and information handling” submitted by Ghina Nazeef have been found satisfactory for the requirement of the degree.

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Dedication

I would like to dedicate this thesis to my parents, who were always there to support and motivate me.

Certificate of Originality

I hereby declare that the research titled "***Supporting conceptual understanding of fifth-grade mathematics students by integrating STEAM intensive activities in teaching area, perimeter and information handling***" is my own work 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 SEECS, NUST 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 SEECS, NUST 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.

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Abstract

The study was conducted to measure the impact of STEAM (Science, Technology, Engineering, Arts and Mathematics) based hands-on activities on 5th graders of a public school in Quetta. Two vast topics (Area & Perimeter and Information Handling) from mathematics curriculum were selected to carry out the intervention. Simple, cost effective and easy hands-on activities were prepared for the participants. A total of 69 students out of 136 participated in a 4-day STEAM activities session where they were allowed to learn through a different medium using art supplies as a tool for learning. Quasi experimental design was selected and analysis of the data collected through it showed that students not only enjoyed the session but their scores significantly improved at the end. The Mann-Whitney test conducted for the analysis for data sets of both sessions indicated that the p-value was greater than 0.05 in post-test as compared to pre-test hence allowing us to reject the null hypotheses in both cases. Engagement level of the students was also improved by the observation that they were helping each other with the tasks and showed keen interest in the activities. Students Engagement in Mathematics Scale (SEMS) proved that the students were more engaged in STEAM based session than their didactic lecture. Due to different staff members for different sections the interest level in mathematics subject differed. Use of more technology oriented supplies other than PowerPoint presentations would have allowed the students to discover and use newer advanced technology. It may have also enhanced their level of participation. For future research, more technology or gender focused hypotheses can be prepared.

Chapter 1: Introduction

The resultant of Arts + STEM (Science, Technology, Engineering and Mathematics) is the new acronym STEAM. Science, Technology, Engineering, Arts and Mathematics (STEAM) education integrates the creativity, sensory, intuitive and distinctive aspects of arts with logical, analytical, objective and beneficial aspects of STEM education (Oner, Nite, Capraro, & Capraro, 2016). The combination of these opposite sides bring about diversity and multiplicity that is important for 21st century innovative product design.

The study would focus on math as a subject that merges its contents with the contents of arts. Both the subject areas come under the STEAM umbrella. Mathematics is usually considered a plain subjects with lots of formulae that one has to memorize in order to solve questions. The purpose of this study is to examine the level of engagement and conceptual understanding through actual test scores of 5th grade Mathematics students by integrating STEAM based hands-n activities in their regular lessons.

This chapter includes introduction to the intervention conducted that take account of the Background, problem statement for the thesis, objectives for the work being done, research questions and their subsequent hypotheses, purpose of the study and a few major limitations.

1.1. Background

Bringing a creative edge to Science, Technology, Engineering and Mathematics (STEM) to problem solve in a constructive environment, teachers and learners are introduced to a more transdisciplinary approach that includes arts – Science, Technology, Engineering and Mathematics (STEAM). STEM subjects are essential for a 21st century learner as well as a teacher but to be successful in any of these content related careers creativity is also significant along with STEM knowledge.

Area & Perimeter and Information handling (Mean, Median & Mode) are two vast topics in 5th grade mathematics curriculum. Both the topics involve multiple tiny concepts that are prerequisites for more complex concepts. These topics may appear simple but often are misunderstood by learners at elementary levels. Students do know the formula but fail to explain the concept behind those formulae (Yeo, 2008). Yeo (2008) also indicates that students sometimes prefer to rote

memorize the formula instead of understanding the concept behind it because they are unable to relate the concept to authentic real-life scenarios.

1.2. Problem Statement

The narrow approach to Science, Technology, Engineering and Mathematics (STEM) arose the need for a more stable approach to learning and teaching was required by the education leaders. This requirement created a space for a more transdisciplinary approach that includes art, design and humanities – Science, Technology, Engineering and Mathematics (STEAM), which is started to appear all over the globe (Quigley & Herro, 2016). STEAM provide teachers an opportunity to explore ways to practice this innovative teaching methodology.

On the other hand, learners would be exposed to critical thinking. Quigley & Herro (2016) explains that critical thinking free learners from boundaries of a single subject and make efforts in linking connections between concepts of Math or Science by means of Technology, Engineering and Arts. The hands-on approach can facilitate students in drawing out conclusions instead of rote memorizing the concepts.

1.3. Objectives

The main objectives of the research are:

- Use hands-on STEAM based activities to make mathematics fun and interesting
- Incorporate content areas that merge the subjects and let the learners' problem solve using authentic scenarios.
- Improve students interest and participation in the subject matter
- To allow alternative learning styles to cater maximum number of students.

1.4. Research Questions & Hypothesis

a. What effect does the integration of STEAM intensive content have on student engagement in the primary mathematics classroom?

Hypothesis A:

H_A – STEAM intensive content increase students' engagement level in a primary mathematics classroom.

b. What is the impact of integrating arts in mathematics classroom on students' mathematics test score?

Hypothesis B:

H_B – Integrating arts in mathematics classroom improve students' mathematics test score.

1.5. Purpose of Study

The study aims to furnish activities that are based on integrative STEAM education fully aligned with the National Curriculum for Mathematics of Pakistan to formulate a STEAM-intensive lesson plans. The outcome of these lesson plans would be in accordance with the Students Learning Outcomes (SLO) as described in the National curriculum of Pakistan and the Common Core State Standards.

With the help of STEAM-intensive lectures, students would be able to problem solve using authentic scenarios because the activities incorporated merge the contents of separate subjects (Quigley & Herro, 2016). Mathematics is a subject where most students fail to converse and link the concepts to the real life (Attard, (2012). The study would also focus on eliminating the gaps between mathematical concepts and daily life situations in a constructive environment.

Initially targeting the primary level, a learners' interest, conceptual understanding through test scores and level of engagement would be measured by introducing STEAM based hands-on activities that provide quality learning with affordable for all resources.

1.6. Limitations

The limitations observed during the research intervention are discussed in this section. First of all, this study was limited to the students of 5th Grade in one school of Quetta. Secondly, the teachers of both boys and girls sections were different so the difference in test scores of pre-test can be observed. Finally, more time and resources could have allowed a greater sample size and more significant results.

Chapter 2: Literature Review

This chapter gives a brief review of the literature related to this study including description of terms and mention of previously conducted researches in the field of STEM and STEAM education.

2.1. Topics under study

The topics selected for intervention in a grade 5 mathematics class were taken from the mathematics book for grade 5 that is a part of National Curriculum of Pakistan. The topics were selected so that school would not change their timeline because of the intervention being conducted.

2.1.1. Area and Perimeter

The concepts of area and perimeter are used constantly in our daily lives – for example, for describing a plot area, size of a house, dimensions of a door or by talking about its floor area. In schools, these concepts are addressed elementary mathematics curriculum (Open.edu, 2015).

Yeo (2008) indicates that even though students give correct answers to standard assessment questions that require a formula, but according to studies people in their middle years (Years 5 to 8) might confuse the theories of area and perimeter. Students may not link what they learn in math class and intuitive understanding of area and perimeter to the real life scenarios. Mostly the students refer to the perimeter as the total distance covered by a figure and the area as length times width. Therefore students do have the conceptual understanding of perimeter but considers area as a formula instead of a concept (Yeo, 2008).

Students also may not be able to understand mathematical vocabulary as it is not always straightforward especially in the case of composite figures where students often have difficulty visualizing the figure (Open.edu, 2015).

2.1.2. Information Handling

Informational handling as described by the National Curriculum of Pakistan is basically statistical measures (Mean, Median and Mode). (Batanero, Burrill, Reading, Batanero, & Jover, 2011)

Around six year-old children start studying statistics as a topic under mathematics subject. They continue to develop these concepts until secondary school (Batanero, Burrill, Reading, Batanero, & Jover, 2011). The misconceptions that arise relative to these statistical measures are as follows:

Mean – Mean is one of the most significant concept of statistics that relates to many everyday applications. Batanero, Burrill, Reading, Batanero, & Jover, (2011) articulates that mean seems to be a simple concept in appearance but it is easily confused if a weighted mean is present in a situation. A weighted mean is then considered as a simple mean. Students mainly focus on memorizing the formula or master the computation to answer a statistical question. However, they have difficulty explaining the concept of mean as their understanding towards it is lacking (Saidi & Siew, 2018).

Median – Mostly the teachers and students conceptualize median as the center point in a frequencies table. Or they consider median to be the middle value of something, or the middle point of the list of numbers before they have been give an order (Batanero, Burrill, Reading, Batanero, & Jover, 2011).

Mode – Saidi & Siew (2018) indicated that students have difficulty understanding the concept of mode and often confuse the three measures of central tendency – mean, median and mode

2.2. STEAM

Designing learning experience for students in a different way along with altered teaching and assessment approaches are the requirements of the new educational environment (Friesen, 2009).

STEAM is an educational approach that guides student inquiry by using Science, Technology, Engineering, the Arts and Mathematics as the basis (STEAM Portal, 2019). The resultant factors are increased experiential learning, improved engagement level, collaboration, and persistence in problem solving and taking thoughtful risks while working through the creative process. The aforementioned factors make up true 21st century learners, leaders and educators.

2.2.1. The importance of ‘A’ in STEAM

To add a creative aspect to STEM education, art is often considered. As experiential learning lead to deeper learning the ‘A’ of STEAM should not be considered a subject but it should be applied in real to problem solve.

- Art teach deep noticing
- Arts emphasize Process
- Arts develop creative confidence

Quigley & Herro, (2016) along with multiple researchers argue that to bring about the creative edge and revolutionary innovations, it is necessary to have art and design skills even though engineers rarely lack creativity. According to Hardiman, Rinne, & Yarmolinskaya, (2014) teaching through arts enhances the academic, cognitive and social skills of a 21st century learner. Arts may incorporate aspects that allow learners to engage and think about constructing information hence improving retention (Hardiman, Rinne, & Yarmolinskaya, 2014). Arts integration is not only the introduction of visual arts, art also includes performing arts such as music, drama and games.

2.2.2. Inquiry based learning

Friesen (2009) says *"former conceptions of knowledge, minds and learning no longer serve a world where what we know is less important that what we are able to do with knowledge in different contexts."* The system of education that most of the world is following at the moment is that which includes teacher centered classroom and it's the same old lecture system. What the students in today's classroom needs, is a different approach that is called Inquiry Based Learning (IBL).

Students should be able to understand a concept deeply therefore they should know how to create and communicate knowledge within specific disciplines. They should know what they are studying about from each and every aspect possible as quoted by Friesen (2009), they should have opportunity to 'play the whole game'.

2.3. Hands-on approach

In a hands-on approach students are engaged in a process or activity, they tend to learn by performing problem solving tasks themselves. Hands-on activities in a classroom avoids passivity and allows learners to engage in interactive learning experiences involving different senses. An applicable pedagogical approach is provided by the hands-on approach. Hands-on activities foster students' conceptual understanding in mathematics by allowing interactivity with mathematical concepts at a deeper level. It allow learners to not only fine the correct answer but also understand the concept behind it (Korn, 2014).

2.4. Engagement in mathematics class

Engagement occurs when students enjoy practicing mathematics, start giving value to learning mathematics and its relevance in their lives and start seeing connections between what they learn and applying it in real lives. However, the issue of lowered level of student engagement in often highlighted when discussing mathematics engagement. This issue limits a child's capability to experience life and understand its meaning through a mathematical perspective (Attard, 2012).

Motivation and engagement are pretty connected and often used together, hence, are sometimes confused. The term 'Motivation' refers to students' self-confidence, how they choose to behave, their capacity to overcome challenges and recovering from academic setbacks. While 'Engagement' as defined by Fredricks, Blumenfeld & Paris (2004) is a multifaceted concept operating at three different levels:

Cognitive Engagement – It allows students to recognize the value of learning, the idea of investment and the willingness to fulfil the requirements of a task (Attard, 2012).

Affective/Emotional Engagement – It involves the students' reaction towards academics, school, teachers and peers that influence their willingness to be involved in school activities (Attard, 2012).

Behavioral/Social Engagement– It includes the concept of students' involvement and active participation social and academic activities (Attard, 2012).

2.5. Tangrams

Tangram is a seven-piece puzzle that originates from China. The puzzle involves arranging different tangrams shapes into animals, geometric figures or objects (Wilkinson, 2008) .Keeping the 'A' of STEAM in mind Tangram seemed a convenient and cost effective solution to teach and learn different topics from mathematics ranging from naming the shapes to finding area and perimeter.

Different aspects to these shapes results in discussion of multiple concepts such as shape, size, symmetry, properties, similarity and area. Tian (2012) explains that the significant aspect of use of tangrams in mathematics is enabling the students to reinforce their ability to visualize a complex figure as multiple simple figures. Learners can also engage in such a discussion where they

mutually find out different shapes and combine them to form one complex shape using tans (Tian, 2012).

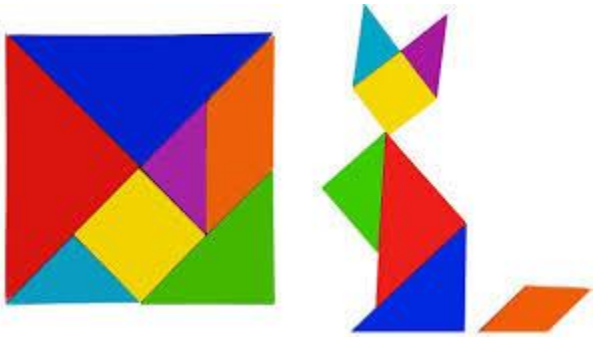

Figure 1: (a) A set of Tangram (b) A Tangram Cat

Chapter 3: Methodology

This chapter includes methodology used, project setting and the art based activities introduced – mapped with The National Curriculum of Pakistan and the Common Core State Standards. The instruments used and the proposed statistical analysis are also discussed. The study targeted at the students of grade 5, focuses on allowing students to learn mathematics through games and activities that are hands-on and are prepared in accordance with STEAM education.

3.1. Research Framework and Design

A quasi-experimental framework design was selected to conduct the research. This framework resembles the true experimental framework but lacks random assignment eliminating the directionality problem (Price, P. C., Jhangiani, R., & Chiang, I. C. A., 2015).

There are different types of quasi-experiments. The type selected for this research is 'Combinations Design'. Combinations design merges the elements of both *non-equivalent group design* and *pretest-posttest design* (Price, P. C., Jhangiani, R., & Chiang, I. C. A., 2015). It identifies a 'treatment group' and a 'control group'. Both groups are given a pretest, the treatment group receives a treatment while the control group does not. A posttest is conducted for both. Both groups selected are sought out to be as similar as possible so they can be fairly compared - but it cannot be said entirely for sure that the two groups are comparable (Trochim, 2006).

The school selected for the intervention was Pakistan Air Force (PAF) Public School, Quetta. Convenience sampling was used for the selection of school based on permission from school administration and staff. A public school was selected after ensuring activities of such kind were not conducted before.

Probability sampling method was adopted for participant selection that included simple random sampling (Trochim, 2006). The selection of sections and division of students into treatment and control group was done randomly. Out of the 4 male sections 2 were selected as control group and 2 as treatment group. Similarly, one female section was selected to be in control group and one to be in treatment group. As the students were young (age group = 9-11 years), a permission letter (Annex. D) was distributed prior to the intervention. A total of 140 students of grade 5 were given the consent form out of which 136 were able to return the form or got the consent. However, the principal of the school and the mathematics staff of grade 5 gave their consent on behalf of their

students. Teacher participation form (Annex. E) was also signed by the two mathematics teachers who taught 5th graders. However, making of videos or recording voices was not allowed only a few pictures were taken during the intervention. Both the consent form were adopted from a prior study at Innovative Technologies of Learning (ITL) at NUST.

3.2. Research Question and Null Hypothesis

The following research questions and their corresponding null hypotheses are formulated for this study:

- What effect does the integration of STEAM intensive content have on student engagement in the primary mathematics classroom?

  Hypothesis A:

  H0 – STEAM intensive content has no effect on students' engagement level in a primary mathematics classroom.

- What is the impact of integrating arts in mathematics classroom on students' mathematics test score?

  Hypothesis B:

  H0 – Integrating arts in mathematics classroom has no impact on students' mathematics test score.

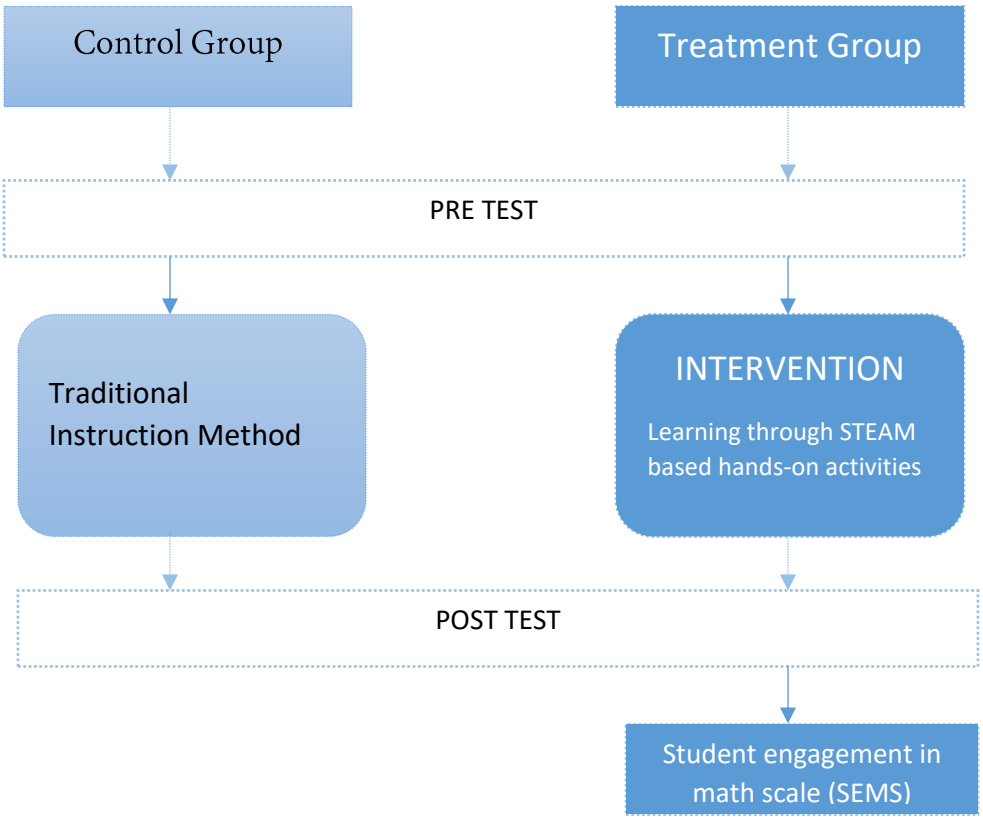

Figure 2: Research Setting

3.3. Research Setting and Method

Around two weeks prior to conducting the intervention a consent form for participation in the study were signed by the mathematics staff i.e. teacher from male section and teacher from the female section. Parent/Guardian Consent forms were handed over to the teachers to be distributed amongst the students. It took more than a week to get most of the consent forms back from the students and to begin the intervention. A total of 136 forms were received out of 140. Six of the participant classes (Grade 5) were randomly assigned to two groups – control and treatment. Out of the six classes 4 were male classes while 2 were female classes. The study does not focus on gender differentiation, therefore only treatment and control groups are mentioned elsewhere.

A total of 4 days were spent on the intervention. Each day had multiple different sessions.

Day 1 (Tangrams):

Session 1: Students were introduced to the researcher and a brief introduction to the activities were given.

Session 2: Pre-test for the topic Area & Perimeter was handed over for a time span of 10 – 15 minutes. The pre-test was prepared in accordance with the National curriculum of Pakistan and the corresponding student learning outcomes (SLOs) also mapped with the Common Core State Standards. The pre-test was to assess the prior knowledge of learners about the topic, Area & Perimeter.

Session 3: After the pre-test was taken, participants of the control group had their regular lecture about the initial concepts of Area & Perimeter while students of the treatment were given the Tangram sets, which they were very excited about. Only a few students had seen or played with a Tangram before. Students were first inquired about the seven Tans separately and if they could identify similar shapes in their surroundings. They had a discussion amongst themselves, quite a number of students were able to identify the types of triangles and were able to make squares and rectangles using Tans. Students were asked to about perimeter to which some replies '*all sides of the shape*', but were hardly able to define area, some replied '*all the shape or the whole shape'.*

Session 4: Using tans, teacher demonstrated the perimeter and area. Students were very interested in the colorful tans and were able to make different silhouettes such as that of cat, car and hat at the end of the session. They were also very keen in keeping the Tangrams set with themselves.

Day 2 (Name Banners):

Session 1: Day 2 was a continuation for the same topic Area & Perimeter but with bit complex concept – composite figures. Students were asked if they knew any simple composite figures. They were unable to answer the question. A simple quadrilateral was drawn to ask about, but they did not know about the name of the figure.

Session 2: Control group had their regular class. A short presentation on laptop was shown to the treatment group to create interest and make learners visualize composite figures. Letters from alphabets were used as examples (Figure). Centimeter scale graph papers were distributed amongst students, initially they were asked to either draw the initial of their names of any other letter they would like on the graph paper. Many students came up quickly while some took some time drawing

the letter. Due to the time constraint students were then as to make a group of 3 students and calculate are and perimeter of one of the composite figure (letter) they have made.

Session 3: After the activity, Post-tests were handed over.

Figure 3: Composite Figures Presentation Slides

Day 3 (Stacking Statistics):

Session 1: Pre-test for the topic Information Handling (Mean, Median, Mode) was given to check pupils understanding of the topic.

Session 2: Control group participants had their regular lecture while treatment group were exposed to the STEAM intensive lesson plan. As soon as students saw paper cups they got excited to try the new activity. They were also somewhat distracted that if they would be able to keep the cups. The students were asked to make groups of 3 in order save time. Each member had a responsibility. First would stack the cups, second would stop the digital timers, and third would record the time for stacking the cups on a record sheet provided. Students would stack 5-cups five times in order to collect data, make a bar graph on the centimeter graph provided and then find out the respective statistical measures.

Day 4:

Session 1: On day 4 post-test for the topic Information Handling was conducted.

Session 2: After the posttest students of the treatment group were provided with Student Engagement in Mathematics Scale (SEMS) to observe students engagement during the STEAM intensive hands-on sessions.

Table 1: Overview of the Intervention

Day 1	Day 2	Day 3	Day 4
• Pretest 1 (Area & Perimeter) • Hands-on activity for treatment group • Traditional lecture for control group	• Hands-on activity for treatment group session 2 • Traditional lecture for control group session 2 • Posttest 1 (Area & Perimeter)	• Pretest 2 (Information handling) • Hands-on activity for treatment group • Traditional lecture for control group	• Posttest 2 (Information Handling) • Student Engagement Checklist provided

3.4. Participants of the Study

The study was conducted on the students of grade 5 (males and females). Of the six sections, 3 were considered control group while the remaining 3 were considered treatment group. The two teachers who participated in the study were both mathematics teachers – one at the male side and the other at the female side – at the respective school. The participation consent form of students and parents are attached in Annex. D and Annex. E, respectively.

3.5. Description of research instrument

Data collection tools to study the hypotheses of research are discussed in this section.

3.5.1. Pre-Tests and Post-Tests

The MCQ (Multiple choice questions) based pretests and posttests were prepared from Grade 5 mathematics textbook, keeping in mind that the questions are not off the context. With maximum score 10, the questions selected mapped with the lessons of mathematics under study. Both the tests are attached in Annex. A & B.

3.5.2. Student Engagement Checklist

Student Engagement in Mathematics Scale was used to assess student engagement after the mathematics class. The scale measures three dimensions of engagement: social, cognitive, and emotional (Rimm-Kaufman, 2010). The scale is attached in Annex. C.

3.6. STEAM intensive lesson plans

The pre-test/post-test and activities are based on The National Curriculum in Pakistan which is followed by the selected school. The topics selected were from the books being used by the students in order to avoid any distraction in the regular timeline and ease of the researcher. They were also selected on the basis that proves that STEAM intensive activities can easily be incorporated in the regular classes and do not require any special separate entity. The activities are simple, cost effective and can easily be search over the internet.

The activities are also mapped with the Students' Learning Outcomes (SLOs) from The National Curriculum of Pakistan and Common Core State Standards as the mathematical progressions presented in the these standards are coherent and based on evidence. Art related content objectives are also part of the Common Core State Standards.

3.6.1. Area & Perimeter Session 1

Table 2: Lesson Plan 1 - Tangrams

Lesson 1	**Tangrams**	
STEAM Subject	**Mathematics**	**Fine Arts**
Content Objectives	Calculate areas by counting squares and perimeters by measuring sides. Use the correct language for shapes	Apply knowledge of available resources, tools, and technologies to investigate personal ideas through the art-making process.
Materials Required	1. Tangram template 2. Scissors 3. Pencils 4. notebooks	
Pre- Test	A short test to measure students learning before conducting intervention	
Engagement	Teachers will introduce tangrams and help students with cutting the template.	
Activity	Students will work in groups of three. They will discuss and write down the mathematical name for each of the 7 pieces. Students will then: - Calculate the area and perimeter of the tangram - Calculate the area and perimeter of each of the 7 pieces - Rearrange pieces to form rectangle and parallelogram. - Calculate area and parameter of the said shapes	
Discussion	What other shapes can you make with all the pieces of the tangram?	
Transition	Show tangram outlines for different shapes	
Closure	Think-Pair-Share would be used as a formative assessment tool.	

Table 3: Student Learning Outcomes for Lesson 1

Student Learning Outcomes Mathematics (Grade 5)	
Code	**National Curriculum of Pakistan**
7.2 (i)	Define Triangle
7.2 (ii)	Define triangles with respect to their sides (i.e., equilateral, isosceles and scalene triangle).
7.3 (i)	Recognize the kinds of quadrilateral (square, rectangle, parallelogram, rhombus, trapezium and kite)
8.1 (i)	Recognize region of a closed figure.
8.1 (ii)	Differentiate between perimeter and area of a region.
8.1 (iii)	Identify the units for measurement of perimeter and area.
8.1 (iv)	Write the formulas for perimeter and area of a square and rectangle.
8.1 (v)	Apply formulas to find perimeter and area of a square and rectangular region.
8.1 (vi)	Solve appropriate problems of perimeter and area.
	The National Curriculum in England Framework
	Solve problems involving addition, subtraction, multiplication and division and a combination of these in contexts
	Measure and calculate the perimeter of composite rectilinear shapes in centimeters and meters
	Calculate and compare the area of rectangles (including squares), and including using standard units, square centimeters (cm2) and square meters (m2) and estimate the area of irregular shapes
	Use the properties of rectangles to deduce related facts and find missing lengths and angles
	Distinguish between regular and irregular polygons based on reasoning about equal sides and angles.
	Common Core State Standards
CCSS.MATH.CONTENT.5.G.B.3	Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category.
CCSS.MATH.CONTENT.5.G.B.4	Classify two-dimensional figures in a hierarchy based on properties.

3.6.2. Area & Perimeter Session 2

Table 4: Lesson Plan 2 - Name Banners

Lesson 2	**Name Banners**	
STEAM Subject	**Mathematics**	**Fine Arts**
Content Objectives	To be able to find out area and perimeter of composite figures by visualizing them as squares and rectangles.	Draw and identify symmetric shapes.
Materials Required	1. Square Centimeter Graph Paper 2. Pencil 3. Scale 4. Colors (optional)	
Pre- Test	A short test to measure students learning before conducting intervention	
Engagement	Teachers will demonstrate an example area and perimeter from classroom surrounding. A short power point presentation would be given to students so that they can better visualize a composite shape.	
Activity	Students will work individually. Students will be given square centimeter graph papers and will be asked to make letters in their names. First they will find the area and perimeter of each letter and add those together to find the area and perimeter of their entire name.	
Discussion	Students can help each other out by helping visualize how a letter can be made out of squares.	
Transition	Students can discuss various composite shapes present in the surrounding. These letters can also be used to introduce angles (acute, obtuse and right angles).	
Closure	Students can color their letters as they want. Think-pair-share would be used as a formative assessment tool.	

Table 5: Student Learning Outcomes for Lesson 2

Student Learning Outcomes Mathematics (Grade 5)	
Code	**National Curriculum of Pakistan**
7.3 (i)	Recognize the kinds of quadrilateral (square, rectangle, parallelogram, rhombus, trapezium and kite).
7.3 (ii)	Use protractor, set squares and straightedge/ruler to construct square and rectangle with given side(s).
8.1 (iv)	Write the formulas for perimeter and area of a square and rectangle.
8.1 (v)	Apply formulas to find perimeter and area of a square and rectangular region.
8.1 (vi)	Solve appropriate problems of perimeter and area.
	Cambridge Primary Mathematics Curriculum
5Gs2	Recognize reflective symmetry in regular polygons.
5Gs3	Create patterns with two lines of symmetry.
5Gs5	Recognize perpendicular and parallel lines in 2D shapes, drawings and the environment.
5Ma1	Measure and calculate the perimeter of regular and irregular polygons.
5Ma2	Understand area measured in square centimeters (cm2)
5Ma3	Use the formula for the area of a rectangle to calculate the rectangle's area
	Common Core State Standards
CCSS.MATH.CONTENT.5.G.B.3	Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category.
CCSS.MATH.CONTENT.5.G.B.4	Classify two-dimensional figures in a hierarchy based on properties.

3.6.3. Information Handling Session

Table 6: Lesson Plan 3 - Stacking Statistics

Lesson 3	**Stacking Statistics**	
STEAM Subject	**Mathematics**	**Fine Arts**
Content Objectives	Arrange and organize data on line and bar plots. Find mean, median and mode of data	Show the relationship between effort and skill improvement over a determined amount of time through charting a performance.
Materials Required	1. Paper Cups 2. Stopwatch 3. Chart Paper 4. Pens / Pencils 5. Graph Sheets	
Pre- Test	A short test to measure students learning before conducting intervention	
Engagement	Teachers will demonstrate several cup-stacking strategies and levels – (3-cup stack, 6-cup stack, 10-cup stack.)	
Activity	Students will work in pairs and will do a 6-cup stack 4 times. Partners will record times using a stopwatch. All data will be added to a classroom chart. The chart will have each students' name and will have a space for all 4 times. Students will be provided with a data sheet to record their data.	
Discussion	Discussion will be guided by teachers to a bar graph plot using the classroom-wide data, which will be modeled for students. Students will then create a bar graph using the same data, and teachers will demonstrate how to find the mode, median and mean.	
Transition	The same data may be used for plotting line graphs.	
Closure	Think-Pair-Share would be used as a formative assessment tool.	

Table 7: Student Learning Outcome for Lesson 3

Student Learning Outcomes Mathematics (Grade 5)	
Code	**National Curriculum of Pakistan**
5.2 (ii)	Add and subtract units of time with carrying /borrowing.
5.2 (iv)	Solve real life problems involving addition and subtraction of units of time.
9.1 (i)	Define an average (arithmetic mean).
9.1 (ii)	Find an average of given numbers.
9.1 (iii)	Solve real life problems involving average.
9.2 (i)	Draw block graphs or column graphs.
9.2 (ii)	Read a simple bar graph given in horizontal and vertical form.
9.2 (iii)	Interpret a simple bar graph given in horizontal and vertical form.
9.2 (iv)	Define and organize a given data.
	The National Curriculum in England Framework
	Solve problems involving addition, subtraction, multiplication and division and a combination of these in contexts
	Solve comparison, sum and difference problems using information presented in a line graph.
	Complete, read and interpret information in tables, including timetables
	Solve problems involving units of time
	Common Core State Standards
CCSS.MATH.CONTENT.5.G.A.1	Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin)
CCSS.MATH.CONTENT.5.G.A.2	Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.
CCSS.MATH.CONTENT.5.MD.B.2	Make a line plot to display a data set of measurements in fractions of a unit

Chapter 4: Data Analysis and Results

In this section, the results and analysis of the collected data is discussed. This study was conducted to measure the impact of STEAM based hands-on activities on engagement and test scores of 5th Grade mathematics students.

Independent samples statistical tests are carried out for evaluating the differences between the two independent samples (Control Group and Treatment Group). IBM SPSS for Windows was used to perform the statistical analysis with 0.05 level of significance.

4.1. Analysis of Pre-test and Post-test scores

Two sets of pretests and posttests were gathered in accordance with the two math topics selected for the study. Analysis of both test sets is discussed in the following subsections.

4.1.1. Pre-Test and Post-test 1 – Area & Perimeter

The student were assessed for the existing knowledge about Area & Perimeter in Pretest1. The treatment group were taught through STEAM based hands-on activities while the control group was taught using their didactic method. The session was divided into two days due to the vastness of the topic. In session 1, basic concepts related to Area & Perimeter were taught. In session 2, advance concepts like composite figures were introduced. Posttest was conducted at the end of Day 2. Both the tests were the same.

Table 8 shows the total number of participants for pre-test 1 and post-test 1. A total of 136 students participated of which 69 students made the treatment group while the remaining 67 students were in the control group.

Table 8: Total number of participants for Pre-Test1 and Post-Test1

		Valid		Missing		Total	
	Group	N	Percent	N	Percent	N	Percent
PreTest1	Experimental	69	100.0%	0	0.0%	69	100.0%
	Control	67	100.0%	0	0.0%	67	100.0%
PostTest1	Experimental	69	100.0%	0	0.0%	69	100.0%
	Control	67	100.0%	0	0.0%	67	100.0%

Table 9 gives descriptions about the two groups: control and experiment during the pretest 1. These descriptions include mean, median, standard deviation and skewness.

Table 9: Description of statistical measures for Pre-Test1

	Group			Statistic	Std. Error
PreTest1	Experimental	Mean		3.55	.145
		95% Confidence Interval for Mean	Lower Bound	3.26	
			Upper Bound	3.84	
		5% Trimmed Mean		3.58	
		Median		4.00	
		Variance		1.457	
		Std. Deviation		1.207	
		Minimum		0	
		Maximum		6	
		Range		6	
		Interquartile Range		1	
		Skewness		-.407	.289
		Kurtosis		.505	.570
	Control	Mean		4.07	.186
		95% Confidence Interval for Mean	Lower Bound	3.70	
			Upper Bound	4.45	
		5% Trimmed Mean		4.04	
		Median		4.00	
		Variance		2.313	
		Std. Deviation		1.521	
		Minimum		0	
		Maximum		8	
		Range		8	
		Interquartile Range		2	
		Skewness		.163	.293
		Kurtosis		.225	.578

Results of the pretest 1 scores indicate that the mean of the experimental group (Mean=3.55) is lower than the mean of the control group (Mean=4.07). While the median for both the groups is same (Mdn=4.00)

Results for the posttest 1 are as follows

Table 10: Description of statistical measures for Post-Test1

PostTest1	Experimental	Mean		7.94	.125
		95% Confidence Interval for Mean	Lower Bound	7.69	
			Upper Bound	8.19	
		5% Trimmed Mean		8.02	
		Median		8.00	
		Variance		1.085	
		Std. Deviation		1.042	
		Minimum		5	
		Maximum		9	
		Range		4	
		Interquartile Range		1	
		Skewness		-1.088	.289
		Kurtosis		.708	.570
	Control	Mean		5.81	.222
		95% Confidence Interval for Mean	Lower Bound	5.36	
			Upper Bound	6.25	
		5% Trimmed Mean		5.88	
		Median		6.00	
		Variance		3.310	
		Std. Deviation		1.819	
		Minimum		2	
		Maximum		9	
		Range		7	
		Interquartile Range		3	
		Skewness		-.543	.293
		Kurtosis		-.474	.578

Results of the posttest 1 scores indicate that the mean of the experimental group (Mean=7.94) is significantly greater than the mean of the control group (Mean=5.81). While the median for the experimental group (Mdn=8.00) is greater than the median of the control group (Mdn=6.00).

To select an appropriate statistical test to analyze the data we had to check if the data gathered was normally distributed. All four Z values are within the range. Our data are a little skewed and kurtotic for both experimental and controlled group, but it does not differ significantly from normality. We can assume that data are approximately normally distributed in terms of skewness and kurtotsis. Shapiro-Wilk test for normality was applied. Table 11 shows the normality tests for pretest1 and posttest1.

Table 11: Normality test for Pre-test1 and Post-test1

Tests of Normality

	Group	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
PreTest1	Experimental	.196	69	.000	.929	69	.001
	Control	.161	67	.000	.951	67	.010
PostTest1	Experimental	.305	69	.000	.809	69	.000
	Control	.199	67	.000	.921	67	.000

For both the tests, it can be observed that data is not normal as $p<0.05$. As the data is not normally distributed, a non-parametric test would be applied to further analyze it.

Non-parametric tests are assumption-free tests as they do not require as many assumptions unlike parametric tests (Field, 2013). The two tests that are preferred when comparing two independent groups are the Wilcoxon Rank-sum test and the Mann-Whitney test. The Mann-Whitney test looks for differences in groups in the ranked positions of the scores (Field, 2013).

The results are shown in Table 12 along with the actual statistics of the Mann-Whitney test, the Wilcoxon procedure and the z-scores.

Table 12: Mann-Whitney U Test for Pre-test1 and Post-test1

	Group	N	Mean Rank	Sum of Ranks
PreTest1	Experimental	69	62.05	4281.50
	Control	67	75.14	5034.50
	Total	136		
PostTest1	Experimental	69	91.80	6334.50
	Control	67	44.50	2981.50
	Total	136		

Test Statistics[a]

	PreTest1	PostTest1
Mann-Whitney U	1866.500	703.500
Wilcoxon W	4281.500	2981.500
Z	-1.996	-7.183
Asymp. Sig. (2-tailed)	.046	.000

a. Grouping Variable: Group

For Pre-test1 the p-value is below 0.05. For Post-tes1 the p-value is above 0.05 hence we keep the hypothesis that the experimental group scored better than the control group and reject the null hypothesis.

4.1.2. Pre-Test and Post-test 2 – Information Handling

The tests for the second topic under study – Information Handling – were conducted similar to the first. Both the pretest and posttest were same. Intervention was conducted for participants of the treatment group after examining their prior knowledge through pretest. Control group participants had their regular lecture of the same topic. Posttest was conducted for both groups at the end.

Table 13 shows the total number of participants for pre-test 2 and post-test 2. A total of 136 students participated of which 69 students made the treatment group while the remaining 67 students were in the control group.

Table 13: Total number of participants for pre-test2 and post-test2

		Cases					
		Valid		Missing		Total	
	Group	N	Percent	N	Percent	N	Percent
PreTest2	Experimental	69	100.0%	0	0.0%	69	100.0%
	Control	67	100.0%	0	0.0%	67	100.0%
PostTest2	Experimental	69	100.0%	0	0.0%	69	100.0%
	Control	67	100.0%	0	0.0%	67	100.0%

Table 14 gives descriptions about the two groups: control and experiment during the pretest 2. These descriptions include mean, median, standard deviation and skewness.

Table 14: Description of statistical measures for Pre-Test2

	Group			Statistic	Std. Error
PreTest2	Experimental	Mean		3.93	.204
		95% Confidence Interval for Mean	Lower Bound	3.52	
			Upper Bound	4.33	
		5% Trimmed Mean		3.96	
		Median		4.00	
		Variance		2.862	
		Std. Deviation		1.692	
		Minimum		0	
		Maximum		8	
		Range		8	
		Interquartile Range		2	
		Skewness		-.183	.289
		Kurtosis		.023	.570
	Control	Mean		5.13	.163
		95% Confidence Interval for Mean	Lower Bound	4.81	
			Upper Bound	5.46	
		5% Trimmed Mean		5.13	
		Median		5.00	
		Variance		1.785	
		Std. Deviation		1.336	
		Minimum		2	
		Maximum		8	
		Range		6	
		Interquartile Range		2	
		Skewness		-.135	.293
		Kurtosis		-.467	.578

Results of the pretest 2 scores indicate that the mean of the experimental group (Mean=3.93) is lower than the mean of the control group (Mean=5.13). While the median the experimental group (Mdn=4.00) is also lower than the median of the control group (Mean=5.00)

Results for the posttest 2 are as follows

Table 15: Description of statistical measures for Post-Test2

	Group			Statistic	Std. Error
PostTest2	Experimental	Mean		8.71	.122
		95% Confidence Interval for Mean	Lower Bound	8.47	
			Upper Bound	8.95	
		5% Trimmed Mean		8.77	
		Median		9.00	
		Variance		1.032	
		Std. Deviation		1.016	
		Minimum		6	
		Maximum		10	
		Range		4	
		Interquartile Range		1	
		Skewness		-.683	.289
		Kurtosis		.078	.570
	Control	Mean		6.81	.194
		95% Confidence Interval for Mean	Lower Bound	6.42	
			Upper Bound	7.19	
		5% Trimmed Mean		6.82	
		Median		7.00	
		Variance		2.522	
		Std. Deviation		1.588	
		Minimum		3	
		Maximum		10	
		Range		7	
		Interquartile Range		2	
		Skewness		-.045	.293
		Kurtosis		-.632	.578

Results of the posttest 2 scores indicate that the mean of the experimental group (Mean=8.71) is significantly greater than the mean of the control group (Mean=6.81). While the median for the experimental group (Mdn=9.00) is also greater than the median of the control group (Mdn=7.00).

To select an appropriate statistical test to analyze the data we had to check if the data gathered was normally distributed. All four Z values are within the range. Our data are a little skewed and kurtotic for both experimental and controlled group, but it does not differ significantly from normality. We can assume that data are approximately normally distributed in terms of skewness and kurtotsis. Shapiro-Wilk test for normality was applied. Table 16 shows the normality tests for pretest 1 and posttest 1.

Table 16: Normality Tests for Pre-Test2 and Post-test2

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
PreTest2	Experimental	.132	69	.004	.959	69	.024
	Control	.174	67	.000	.943	67	.004
PostTest2	Experimental	.264	69	.000	.873	69	.000
	Control	.142	67	.002	.957	67	.020

For both the tests, it can be observed that data is not normal as $p<0.05$. As the data is not normally distributed, a non-parametric test would be applied to further analyze it.

As data are non-parametric Mann-Whitney U test was applied. The results are shown in Table 17 along with the actual statistics of the Mann-Whitney test, the Wilcoxon procedure and the z-scores.

Table 17: Mann-Whitney U for Pre-Test2 and Post-Test2

Ranks

	Group	N	Mean Rank	Sum of Ranks
PreTest2	Experimental	69	54.64	3770.50
	Control	67	82.77	5545.50
	Total	136		
PostTest2	Experimental	69	90.77	6263.00
	Control	67	45.57	3053.00
	Total	136		

Test Statistics[a]

	PreTest2	PostTest2
Mann-Whitney U	1355.500	775.000
Wilcoxon W	3770.500	3053.000
Z	-4.238	-6.826
Asymp. Sig. (2-tailed)	.000	.000

a. Grouping Variable: Group

For Pre-test 2 the p-value is below 0.05. For Post-test 2 the p-value is above 0.05 hence we keep the hypothesis that the experimental group scored better than the control group and reject the null hypothesis.

4.2. Analysis of Student Engagement in Mathematics Scale (SEMS)

The Student Engagement in Mathematics Scale (SEMS) was filled by the students at the end of day 4. The checklist is based on a Likert scale to assess student engagement after the mathematics class. The scale consists of 13 statements that measures three dimensions of engagement: social, cognitive, and emotional (Rimm-Kaufman, 2010). The scale is attached in Annex. C.

The answers from the checklist were further analyzed and are shared below in graphical form:

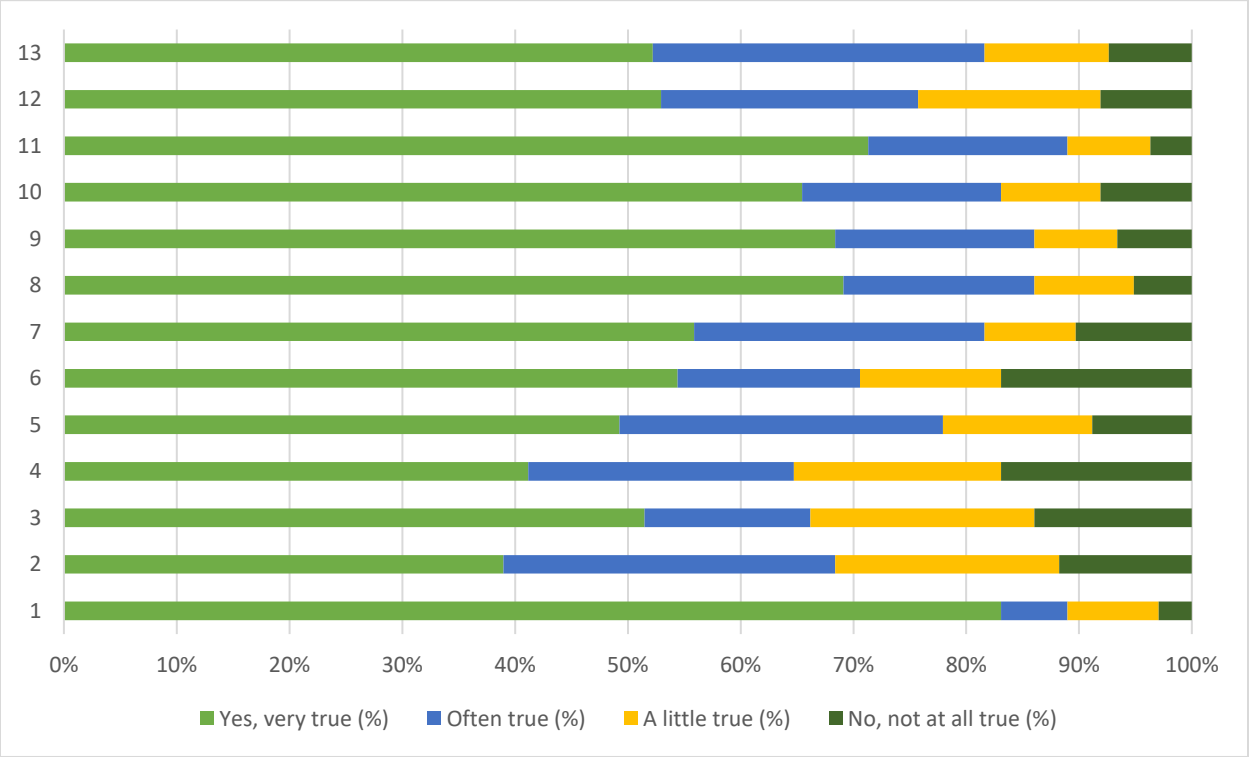

Figure 4: Analysis of Student Engagement in Mathematics Scale (SEMS)

It can be observed from the graph that most of the students showed positive response towards the intervention conducted. The statements of the checklist are divided into 3 groups as mentioned earlier. The statements and their corresponding engagement type are as follows.

Emotional engagement: 6,7,8,11,12

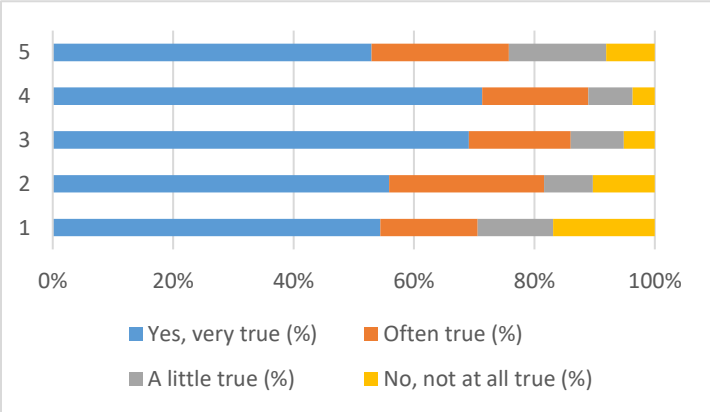

Figure 5: Emotional Engagement

The observations regarding the emotional engagement of the students showed that they had fun during the sessions and enjoyed solving the problems through hands-on STEAM activities. As the students were comparatively not bored during the intervention, they solved the problems with interest.

Social Engagement: 2,3,4,5

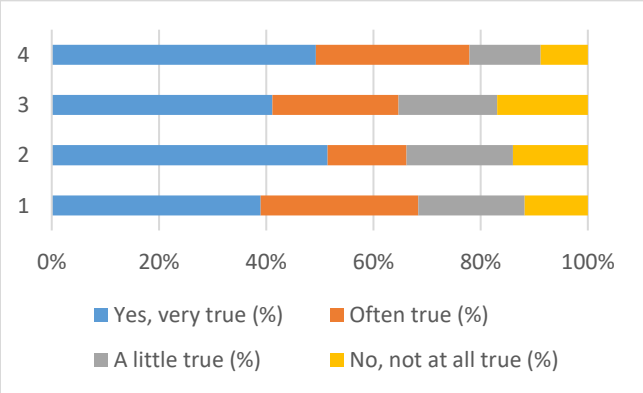

Figure 6: Social Engagement

The results of the observations made related to social engagement clearly suggested that majority of the students were showing positive body language. They discussed and shared their ideas and helped out each other in completing the tasks.

Cognitive engagement items: 1, 9, 10, 13

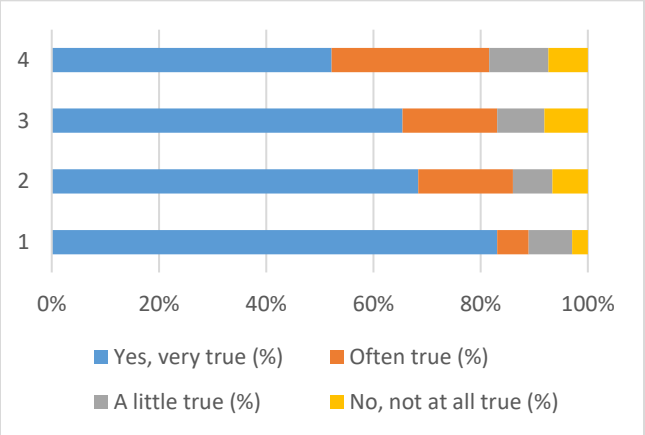

Figure 7: Cognitive Engagement

The observations regarding the student's cognitive engagement showed that majority of them remained interested in the activity and worked as hard as they could. According to the statistics students made sure they think about the topics, understand them and work as hard as they could to grasp the concepts.

Chapter 5: Discussion

The purpose of this research was to measure the impact on tests scores and engagement by including STEAM based hands-on activities into the mainstream mathematics curriculum. This chapter includes some significant discussion points on the basis of the conducted research and the generated results, as shared in the previous chapters.

5.1. Impact of STEAM based hands-on activity on test score of mathematics students.

The null hypothesis stated that integrating arts in mathematics classroom has no impact on students' mathematics test score. As seen in the results of the gathered data the mean for the experimental group (Mean=7.94) and control group (Mean=5.81) in the post test improved as compared to mean for experimental group (Mean=3.55) and control group (Mean=4.07) in the pretest. However a significant difference in the test scores of posttest can be observed between the mean and median of experiment group as compared to the control group, [experiment group: mean=7.94 , median =8.00 | control group: mean= 5.81, median=6.00]. Hence, the null hypothesis was rejected based on the analysis done for the obtained test scores.

Students seemed to have enjoyed the particular style of learning and grasped the concepts quickly, leading to an increase in the test scores.

5.2. Impact of STEAM based hands-on activity on engagement of mathematics student

The null hypothesis stated that STEAM intensive content has no effect on students' engagement level in a primary mathematics classroom. The hypothesis was rejected based on the results of the data collected. Students showed a great amount of interest during the intervention which allowed them to think about the topic, relate it to real life examples and get a better and deeper understanding of the concepts. It was observed that students were not bored during the intervention and enjoyed the session. Students were also very helpful towards their class mates who were having difficulty understanding the tasks or were stuck at any point during the session.

A statement at the end of the Students Engagement in Mathematics Scale (SEMS) asked the participants to write about how they felt in the mathematics sessions. Most of the students wrote

that they liked math and a few left the space blank. However, some of the comments made by the participants are highlighted below.

'*I am happy that I got to know something new, I had so much fun today and it was my favorite class of the whole week. And I loved it.*' (Female Student)

'*It was very fun for me and I learned so much today in my math class.*' (Female Student)

'*Today our math topic was very interesting and fun, I enjoyed it.*' (Female Student)

'*I helped my friend to understand math. We all had fun in math class.'* (Male Student)

'I felt so good and got to learn so much more about math' (Male Student)

'I liked math class because it was interesting. I feel good when I was solving problems of math'' (Male Student)

5.3. Feedback & Observation

These simple STEAM based activities require no expensive material. Such activities can easily be thought of or searched on the internet. There are many other ways in which arts can help teachers in relating school topics to the real world in a fun and creative way. Tangrams and origami are two such examples that can be used to teach mathematics through hands-on practice.

The participants of the study seemed very excited and interested during the intervention. They were very motivated by the fact that they could learn mathematical concepts through games and arts. Their keen interest and improved engagement level could be observed in the results section were the participants of the treatment group performed better in posttest than the participants of the control group.

5.4. Limitations of the study

A few limitations of the study are mentioned in this sub-section:

5.4.1. Limited sources

The research was specific to only one school of Quetta city, with students from similar ethnicity. A diverse range of students could have resulted in a more different experience. Also, an intervention in a government school and a private school would have allowed to observe diverse response and signify the gap between the pedagogy used by the different schools

5.4.2. Limited Time

More time to conduct the intervention would have helped to derive long-term conclusions. Retention could have been measured if more time was allowed. Limited time also disable researchers to maybe completely satisfy the students. As students were excited, they wanted to take most out of the activities, even off the topic things such as coloring the initials drawn on graph paper or keeping the cups of the cup stacking activity.

More time and resources could have allowed a greater sample size and more significant results.

5.4.3. Different teachers for boys and girls

Due to the difference of teachers who taught boys and girls a significant difference is seen between the scores of girls and that of boys. The teacher who taught the boys section seemed stricter and experienced than the teacher who taught girls section. According to a teacher, students are sometimes spoon-fed to avoid any indiscipline.

5.4.4. Limited Resources

Only one researcher was present with assistance of two staff teachers to conduct the intervention. More researchers could have resulted in a better schedule and management of carrying out the intervention. It was quite difficult to handle students as they were young and got easily excited by hearing words '*activities', 'colors',* and *'arts'.* Even the teachers of the respective school responded that they have to spoon feed the students sometime in order to maintain discipline. Two or more researchers and staff members may have resulted in overall better experience.

Chapter 6: Conclusion

The study was conducted to perceive the impact of STEAM based hands-on activities on the test scores and engagement level of the students of grade 5 for the subject Mathematics. The main focus of the study is on the two strands of STEAM – Mathematics and Arts. Students were involved in art related activities to learn mathematics. Technology component of STEAM was also considered on a minimal level. Digital timers and PowerPoint presentation contributed to the technology strand, while the lesson plans had Student Learning Outcomes (SLOs) that mapped both the 'Art' and the 'Mathematics' components. The topics selected for the intervention were Area & Perimeter and Information Handling (Mean, Median and Mode), that comes under the mathematics subject. The topics were selected from the National Curriculum of Pakistan for grade 5 mathematics to ensure that participants do not leave their school timeline.

The previous chapters covered the introduction, methodology, data collected and results from the intervention conducted. To conclude, students did show interest in the introduced STEAM based hands-on activities as the test scores were relatively higher than the students who were part of the control group. The bar graphs and Mann-Whitney test for pre-test and post-test, for both the sessions indicated that the p-value is above 0.05 for the post-tests as compared to the pre-tests, hence allowing us to keep the hypotheses and rejecting the null hypotheses.

There is less creativity and an element of fun in a didactic classroom. Students are often unable to relate mathematics with their surroundings. With the help of **Art** integration with **Mathematics** and **Technology** assistance, students were able to relate the concepts hence improving the level of engagement as well as comparatively improved test scores. Students were better able to visualize the mathematical concepts.

Such easy and inexpensive methods of teaching can help teachers make students understand the concepts deeply by performing hands-on tasks and encouraging them to help each other. A socio-constructive environment emerges as a result of implementing STEAM based hands-on activities. Hands-on practice, discussion and fun may lead to long-term, deeper understanding of a topic and better retention.

Chapter 7: Recommendations

7.1. General Recommendations

The study conducted on 5th grade mathematics students proved that such cost-effective activities can easily be incorporated into an average classroom. The activities were stimulating and can easily be molded according to the class environment. Researchers and teachers can implement similar activities even if they do not have access to digital gadgets. Merging the aspects of arts with any of the topics, be it mathematics or science can result in interactive and thought-provoking sessions. A fair amount have been conducted relative to STEM and STEAM, but specifically for some topics, as considered in this study, are less. More topics can be covered by integrating STEAM intensive activities.

Merging the subjects other than arts and mathematics by preparing lines of inquiry can result in making learners understand one concept through lenses of different subjects. The lines or statements of inquiry revolves around a central idea and involve at least three components of STEAM. The interactivity created amongst students due to integration of STEAM intensive activities is a notion that pupil can work together to construct new idea relating one to another. Such constructive gestures are a need of 21st century learning environments. And increased retention rate is the resultant of learners interacting with each other and building upon their knowledge.

Allowing such an environment to learners, where they learn and grow, is the foremost requirement in 21st century. Project-based and hands-on session that are completely aligned with STEAM stimulates enthusiasm among students, hence creating a sense of eagerness to learn. STEAM is a transdisciplinary approach that is easily applicable and can range from cost effective to expensive tasks as required by the researchers or teachers. Schools may integrate specific topic related activities that keep them bound to their timelines or they may implement STEAM session separately to go a bit out of context and make their students understand the concept instead of sticking to strict timeline.

7.1.1. Recommendations for Future Research

There is a still a much wider scope for research related to STEAM being implanted despite many researches being carried out. STEAM is a vast concept and can undergo various research topics

and levels. Aspects of Art and Engineering can complement the other three strands of STEAM – Science, Technology and Mathematics. STEAM intensive activities make up a captivating educational tool that can easily be implemented at any grade, setting or even for learners who are homeschooled. More subjects can be added to prepare lines of inquiry and conduct intervention to inspect if learners can learn a concept from various angles i.e. different subjects.

Study to find gaps between public and private schools

As the study mainly focused on overall students of a public school. A research to test the same intervention on students of public and private school can be conducted in order to find the gap between the test scores. This study would be able to identify the response of students towards the study.

Gender oriented study

The study conducted did not focus on one gender specifically neither was there any comparison done to measure the effects on different genders. A similar study can be conducted to check the difference in the test scores or engagement level between boys and girls. For a future study, researchers can observe who among the genders respond more effectively to the applied interventions.

More technology focused aspects

For a research to be conducted in a private school more technology based resources can be used to support the lesson plans. Games can be developed to apply STEAM in a smart classroom, for home-schoolers or to learn casually. Technology can help learners visualize the concept better, hence resulting in deeper understanding of the subject matter. Apart from just using power points more advanced yet less costly gadgets such as Google cardboard can be used to create an immersive environment where students can learn and have fun.

Bringing together diverse minds

Pupil from diverse field may work together to prepare STEAM intensive activities that can be implemented in a classroom. Involving experienced educators, technologists and teachers can help researcher understand various aspect of a task being prepared. Subject teachers can advise the topics and concepts that most students are hardly able to understand. Art teachers can suggest the solutions for the corresponding concepts while technologist may come up with approaches to make students eager to learn a new concept.

Chapter 8: References

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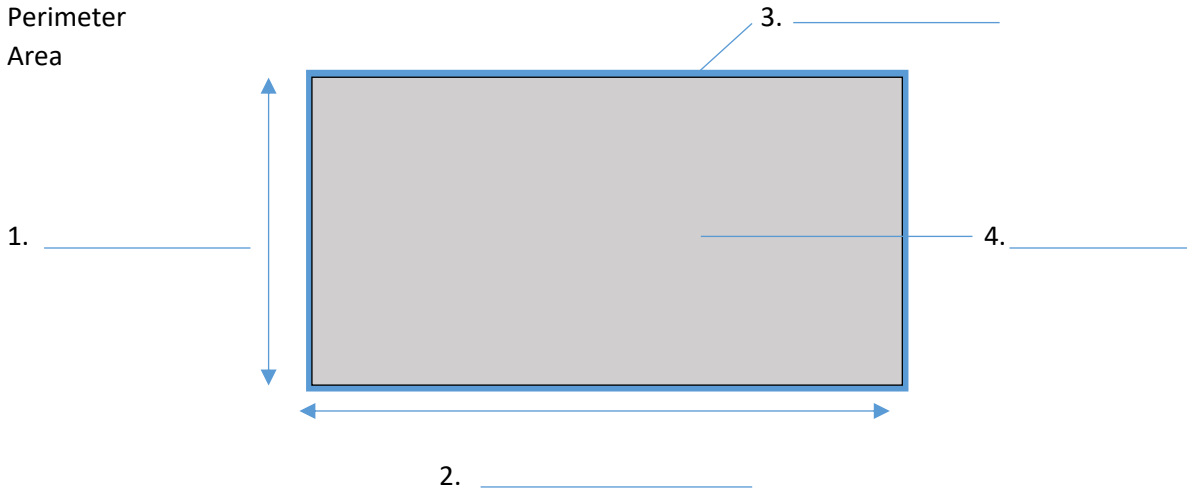
Annex A: Test1 – Area and Perimeter

Pre-Test		
Name:	**Topic: Area and Perimeter**	**Date:**

1. If two sides of a triangle are of equal length, it is called _____
   a. Right-angle triangle
   b. Scalene triangle
   c. Equilateral triangle
   d. Isosceles triangle
2. Quadrilateral with no right angles and equal opposite sides is called _____
   a. Rectangle
   b. Square
   c. Parallelogram
   d. Rhombus
3. Diagonals of _____ are equal and perpendicular.
   a. Rhombus
   b. Kite
   c. Square
   d. Rectangle
4. Perimeter is:
   a. The product all four sides of a geometrical figure
   b. The total distance around a geometrical figure
   c. The product of two sides of a geometrical figure
   d. The total surface covered by a geometrical figure
5. Area is:
   a. The sum of all sides of a geometrical figure
   b. The boundary and interior of a geometrical figure
   c. The total surface covered by a geometrical figure
   d. The total distance around a geometrical figure
6. Label the following diagram with provided options
   a. Length
   b. Width
   c. Region
   d. Perimeter
   e. Area



7. Area of a triangle with length 2cm and base 6cm is
    a. 4cm
    b. 5cm
    c. 6cm
    d. 8cm
8. Formula for perimeter of a rectangle is
    a. Length x Width
    b. 2 x (Length x Width)
    c. Length + Width
    d. 2 x (Length + Width)
9. What is the area of a square with length 5cm?
    a. 20cm
    b. 25cm
    c. 10cm
    d. 12cm

Annex B: Test2 – Information Handling

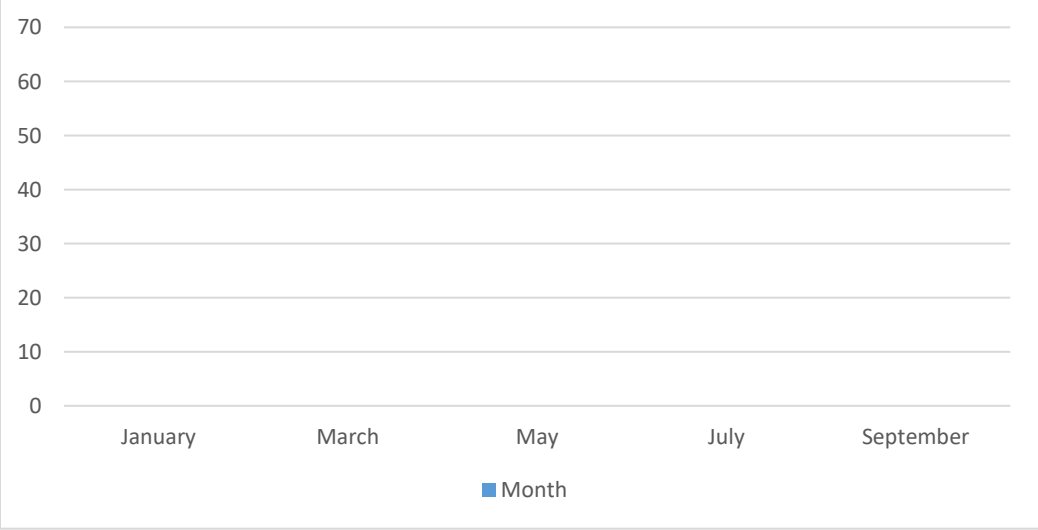
Pre-Test		
Name:	**Topic: Information Handling**	**Date:**

1. Arithmetic mean of some values is _____ of the values divided by total number of values.
   a. Sum
   b. Difference
   c. Product
   d. Quotient
2. What is the average of 10 values if their sum is 200?
   a. 10
   b. 20
   c. 100
   d. 200
3. Numerical form of information is called
   a. Values
   b. Data
   c. Set
   d. Average
4. The number that is repeated most often in a dataset is called _____.
   a. Mean
   b. Median
   c. Mode
   d. Range
5. What would be the median of the following

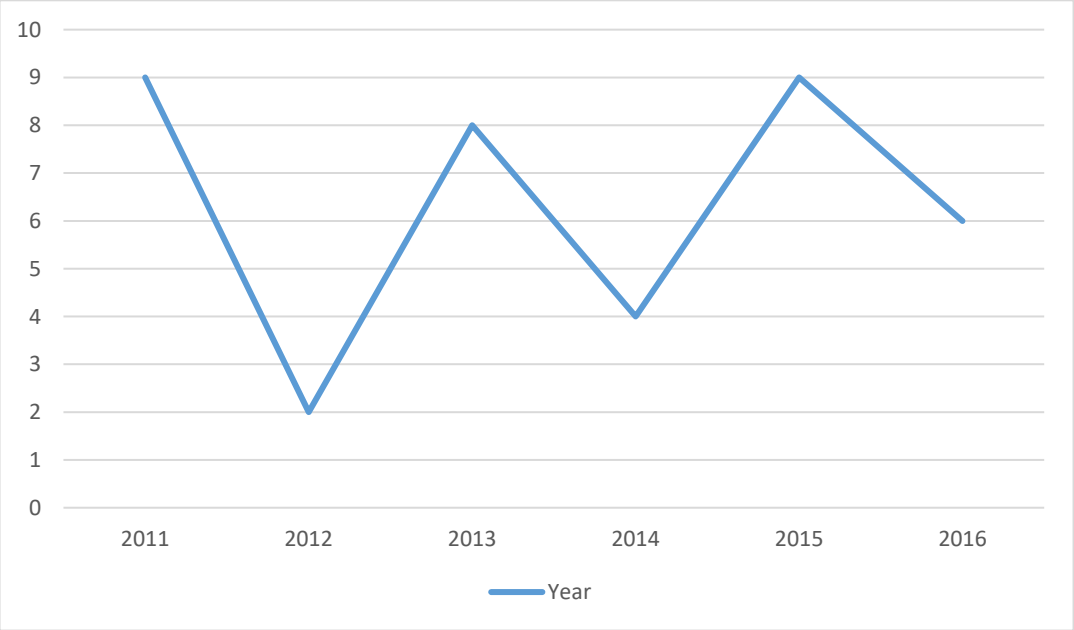
   13, 13, 15, 15, 17, 18, 19, 20

   a. 15
   b. 16
   c. 17
   d. 18
6. Plot a bar graph for the following

Month	January	March	May	July	September
Temperature	10	30	40	60	40



7. The graph shows the number of games won in each year



How many games did the soccer team win in 2016?

a. 9
b. 6
c. 5
d. 7

8. What is the total number of games won from 2011 till 2016?
   a. 36
   b. 32
   c. 38
   d. 34
9. What is the average number of games played from 2011 till 2016?
   a. 5
   b. 6
   c. 7
   d. 8
10. What is the mode for the number of games played from 2011 till 2016?
    a. 2
    b. 4
    c. 8

Annex C: Student Engagement in Mathematics

We are interested in your thoughts about math class today. Please read each statement, and circle the number that fits.

Statement	No, not at all true	A little true	Often true	Yes, very true
1. Today in math class I worked as hard as I could.	1	2	3	4
2. Today I talked about math to other kids in class.	1	2	3	4
3. Today I helped other kids with math when they didn't know what to do.	1	2	3	4
4. Today I shared ideas and materials with other kids in math class.	1	2	3	4
5. Students in my math class helped each other learn today.	1	2	3	4
6. Math class was fun today.	1	2	3	4
7. Today I felt bored in math class.	1	2	3	4
8. I enjoyed thinking about math today.	1	2	3	4
9. Today it was important to me that I understood the math really well.	1	2	3	4
10. I tried to learn as much as I could in math class today.	1	2	3	4
11. Learning math was interesting to me today.	1	2	3	4
12. I liked the feeling of solving problems in math today.	1	2	3	4
13. I did a lot of thinking in math class today.	1	2	3	4

If there is anything else you would like to write about how you felt in math class today please write it below:

Annex D: Parent/Guardian Consent Form

Date: _____

Dear _____

I am a student of MS Innovative Technologies of Learning (ITL) at the School of Electrical Engineering and Computer Sciences (SEECS), NUST, Islamabad. I am currently in my thesis phase where I will be working at your child's school for examining the effects of art-integration in mathematics classroom through Science, Technology, Engineering and Mathematics (STEAM) intensive content.

Your child's name will not be mentioned on any material related to this study. Your signature on this form indicates your voluntary consent for this study.

I have read the information above. I understand by signing this form, I give consent for my child to participate in this research study.

☐ **Yes, I agree.** ☐ **No, I do not agree.** **Childs' Name: _____**

_____ _____ _____

Parents' Name Parents' Signature Date

Annex E: Teacher Participation Consent Form

Date: _____

Dear _____

I am a student of MS Innovative Technologies in Education (ITE) at the School of Electrical Engineering and Computer Sciences (SEECS), NUST. I am currently in my thesis phase where I will be working at your school for examining the effects of art-integration in mathematics classroom through Science, Technology, Engineering and Mathematics (STEAM) intensive content on students of grade 5.

As a teacher participant, if you belong to control group, you will be asked to carry on with your regular lesson plan. Your name will not be mentioned on any material related to this study.

Your signature on this form indicates your voluntary consent to participate in this study.

I have read the information above. I understand by signing this form, I agree to participate in this research study.

_____	_____	_____
Name	Signature	Date

Thank you for taking the time to assist me in the research

Annex F: NUST Permission Letter

To Whom It May Concern:

SUBJECT: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Sir/Madam

It is to inform that Ms. Ghina Nazeef bearing CNIC no: 54400-2173885-2 is a registered student of MS in Innovative Technologies in Education (ITE) program at the School of Electrical Engineering and Computer Sciences (SEECS), NUST, Islamabad.

As a requirement of MS degree she intends to conduct a research in an educational setting under the supervision of Ms. Manzil-e-Maqsood, Assistant Professor and faculty member in the ITE program. Her work will also be directed by Dr. Gulab Khan, Ms. Aleena Qurashi, and Mr. Jaudat Mamoon – all faculty members at SEECS.

The proposed title of her research is "*Supporting conceptual understanding of fifth-grade mathematics students by integrating STEAM intensive activities in teaching area, perimeter and information handling*". The study aims to promote creativity amongst students by introducing (Science, Technology, Engineering, Arts and Mathematics) STEAM intensive content to enhance their mathematical concepts.

The expected duration of the research intervention and data collection would be two weeks. It is, hereby, requested you to allow her to conduct research in your esteemed institution. She will also be presenting you with a parental and teacher consent forms.

Should you require any further information, please do not hesitate to contact the research candidate at email address: gnazeef.msite15seecs@seecs.edu.pk

Your permission to conduct this study will be highly appreciated.

Yours sincerely,

Ms. Manzil-e-Maqsood

Assistant Professor

Innovative Technologies in Education (ITE), SEECS, NUST

Email: manzil.maqsood@seecs.edu.pk Tel: +92 (0) 51 9085 2154