
**ADA UNIVERSITY**

**SCHOOL OF EDUCATION**

**MASTER OF ARTS IN TEACHING AND LEARNING**

**CAPSTONE PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN TEACHING AND LEARNING**

# ACTIVITY-BASED LEARNING DURING MATH CLASSES

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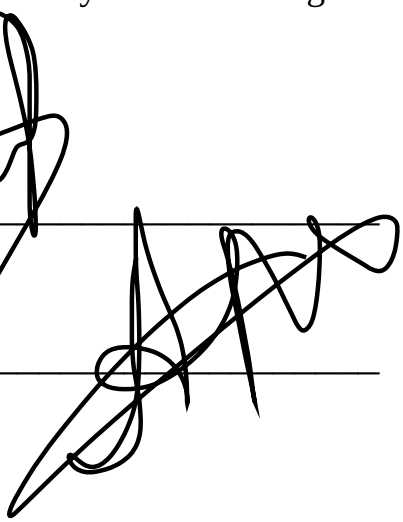

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## ABSTRACT

The purpose of the study was to explore students' and instructors' perceptions about teaching and learning Math and pilot the Capstone Project's end product Activity Toolbox designed to teach Trigonometric functions unit via activity-based learning approach. Qualitative research design was applied in this study. The research sought to receive an answer to the research question, "Does using of activity-based learning engage students in learning Mathematics and assist teachers in instructing them?" The first stage consisted of semi structured individual interviews conducted with four Math teachers to generate information about teaching and learning Mathematics and activity-based learning. Two focus group interviews administered with the 10th graders aimed at collecting high-quality data in a social context and understanding the specific problem, teaching Trigonometric functions unit.

Second stage of the study was piloting activities from the Activity Toolbox. Types of activities were chosen considering Math teachers' and $10^{th}$ graders' answers obtained during the interview process and then, designed. ADA School Math instructors piloted random activities from the Toolbox while teaching the tenth graders in the on-line classes, and we observed them. After the observations, interviews with the same instructors after the piloting assisted to gather their reflections about activity-based learning and piloted activities. To validate the data obtained from the observations and post -piloting interviews with the Math teachers, data triangulation was applied.

The major finding of the Capstone Project was that ABL may have positively affected the tenth graders' Math learning at ADA School based on the results of observations and Math teachers' post- piloting interviews. The study allowed to conclude that Instructions Checking Questions helped students easily handle understanding instructions of ABL and the Trigonometric functions unit taught during the observed classes where activities from Toolbox were utilized.



**Keywords:** *activity-based learning; mathematics; engagement; activity-based instruction.*

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# Chapter 1: Introduction

## Background

Education is a field where teaching and learning have the same level of significance to achieve the goal of developing knowledgeable, innovative and skilled individuals. Hence, education is also responsible to equip individuals with the appropriate knowledge in a right way, and to accomplish this task successfully, integrated teaching and learning environment is needed. As the integrated teaching and learning environment assists students in making connections, finding meaning through such an educational process makes it student centered.

According to Rodrieguez (2018), there are two categories of teaching methods that is simply passing information without extra efforts and enabling students to learn and remember the subject via engaging them in a creative way. Also, Ptress (2008) states that if learning occurs passively, it can lead to factual regurgitation of new material rather than interpretation and application of acquired knowledge. Passively learned content is easily forgotten and ineffectively utilized (Koehler & Mishra, 2008). Passive learning as a process mostly provides the knowledge of algorithmic solutions of problems where teacher just demonstrates the method "Do as I have done" (Koehler & Mishra, 2008). Considering a number of formulas that are difficult to remember and complex problems that may be boring for students, it is pivotal to apply different approaches to achieve higher-level of learning rates in Math classes. One of such major approaches according to Harfield et al. (2007) is Activity-Based Learning (ABL) that is constantly engaging students in active learning instead of passively instructing them during the classes. ABL is applied by using various activities that enable students learn faster in an effective way and remember the subject.

## Problem Statement

Based on self-observations and regular peer observations conducted at ADA School, we witness low engagement in Math classes, where Trigonometric functions remains one of the most complicated units for the tenth graders. The main complication is caused by the overloaded course content, which means while some units consist of 10-12 lessons, this particular unit encompasses 50 lessons. Besides, students are not interested in lecture-based lessons that lead to low engagement in Math classes. Both self-observations and peer observations revealed that when Math instructors apply activity-based learning in class, students become more interested and engaged than in lecture-based lessons. In order to increase students' interest and engagement I, Nigar Aghayeva, and Mujgan Aliyeva decided to design "Activity Tool-Box" that introduces activity-based learning tasks for Trigonometric functions unit for X grade.

ADA School is a high school located in Baku, Azerbaijan. At this school, the instructional language is English. At ADA School 10 math instructors teach 236 $10^{th}$ and 190 $11^{th}$ graders attending Math classes. Due to the COVID-19, ADA School has translated to online mode. The-online education has significantly affected the effectiveness of the studies. Nevertheless, the importance of teaching and learning Math at ADA School remains the same. Yet, the main problem that needs to be attended to is the passive style of teaching Math Before the COVID-19 pandemic in face-to-face classes, the instructors used to spread worksheets or hand-outs with formulas, and students were supposed to learn the provided material. In addition, Math classes included problem solving tasks to practice studied topics. The same teaching approach is currently applied in on-line Math classes at ADA School. Apparently, the instructors have not included activity-based learning either in face-to-face or in on-line Math classes at ADA School.

## Purpose of the Study

The purpose of the study is to explore students' and instructors' perceptions about teaching and learning Math and pilot the Capstone Project's end product Activity Toolbox designed to teach Trigonometric functions unit via activity-based learning approach.

## Significance of the Study

Mathematics is one of the complex subjects taught in high-schools, and it is among the mostly demanded ones for higher levels of education and better job opportunities in future (National Research Council, 1998). Thus, there is a significant need for improving learning and teaching approaches in Math classes. Unfortunately, most Math classes are designed based on passive learning model while activity-based learning techniques have shown positive impact on the learning rates of students (Koehler & Mishra, 2008). Considering the importance of Math for students and the gaps in teaching Mathematics, it is significant to examine this issue for both practitioners and researchers.

This Capstone Project's end product may help engage students to learn Trigonometric functions unit and make lessons more interesting. The Activity Toolbox may assist not only Math instructors at ADA High School, but also other Math teachers to teach Trigonometric Functions in local and private schools of Azerbaijan.

## Research Question

*Does using of activity-based learning engage students in learning Mathematics and assist teachers in instructing them?*

## Chapter 2: Literature Review

The review of literature mainly focuses on activity-based learning and its impact on Mathematics classes. Different aspects from previous studies regarding activity-based learning, its impacts on Mathematics classes, and methods to boost the implementation of this type of learning have been substantially reviewed. Activity-based learning applied in 1944 around World War II by David Horsburgh (Hindu, 2004). Hence, it was not the first attempt to implement activity-based learning as the initial resource found was a photo in the 1942 yearbook of Shimer College captioned “Hey kids, what’s cooking?” (Shimer College, 1942).

Given the importance of students’ active learning, low achievement in Math classes has remained as one of the areas of concerns for researchers and practitioners. Using an empirical study, Krapp (1999) focused on analyzing students’ achievement rate based on their interests. The study was designed to study two variables: learning outcomes as a dependent variable and interest factor as an independent variable. Achievement rates in Math classes usually depend on variables such as pupils’ interest, motivation, the ability to learn, and the quality and effectiveness of the classes (Krapp, 1999).

Since interest has been considered to have a significant impact during class activities, Kiili (2007) analyzed learning mechanism in educational games. The qualitative analysis has revealed the outcomes of applying gaming in education process. The study provides analysis based on the Problem-Based Gaming model since it is one of the most important learning mechanisms applied in education. With the sample of 24 participants, the author concluded that learning is enhanced by reflection. Since the participants tended to perform better understanding of the problem domain by analyzing different strategies actively, it should be noted that this approach may simulate double loop learning.

## Activity-Based Learning

To increase the effectiveness of learning Math, both practitioners and the researchers offered solutions. Over the past 4000 years pedagogues have been suggesting activity-based learning as a way of enhancing motivation and thinking (Triadafillidis, 1993). According to Triadafillidis (1993), students should not only protect the silence in class simply listening to the teachers' instructions, instead they should actively participate in class.

Previously, Lauren (1987) stated that students should be provided with the opportunities and supported to gain abilities to address real-life problems instead of passively listening to lectures during the class. The researcher conducted the quantitative study and concluded that activity-based learning played a significant role in increasing students' achievement rate. Taking this factor into account, the author analyzed the effects of project-based learning as the part of activity-based learning. The study revealed that formal and analytic modes were the main approaches for teaching Math to students. Due to the implemented modes of learning, students considered tasks as an activity that needed to be accomplished within a defined period of time (Triadafillidis, 1993). According to the researcher, the implementation of project-based learning helped students to feel more ready or confident defending their solutions. The study is significantly against the approach of "Do what I say" in Math classes. Implementation of project-based learning may change significantly since the results may differ among primary, secondary, and high school students (Triadafillidis, 1993).

Solutions to increase the efficiency in learning Math at primary school has been analyzed for years. Shamali (2018) also conducted a research that analyzed the methods to increase the efficiency of Math lessons. The author focused on the role of activity-based teaching method to

improve the efficiency in Math through the analysis of previous studies carried out centuries before.

Likewise, Froebel (1826) stated, “Activities and playing are the highest expression of human development in childhood” (p. 90). Instead of focusing on how activity-based learning improves learning in Mathematics classes, the author concentrated on how to improve the implementation level of activity-based learning. The author analyzed the primary mathematics teachers’ perceptions on the use of activity-based learning (ABL). Froebel (1826) created instructional model to develop activities that could improve activity-based teaching methods. Based on the quantitative analysis, the study revealed that ABL helped to improve classroom interaction and enhance student retention in Mathematics. Moreover, the study showed that major problems during the implementation of ABL were lacking instructional materials and resources. When the class size was larger and time allocated for the classes was not enough or inadequate, to accomplish activities in class and within limited time remained problematic (Froebel, 1826). To find a solution to increase efficiency of learning in Math classes, outdoor activities were arranged by Froebel (1826). These activities led to 100% enthusiasm for learning by students and 100% expectation by instructors to arrange activity-based learning in future (Froebel, 1826). Considering that most of the schools did not apply activity-based learning, the research focused on exploring ABL implementation and as a result, the research proved the positive outcomes of activity-based learning implementation at schools.

While learning foundation of math is significant phase to consider, protecting the high achievement rate of Math at high school is also important. Chelik (2018) analyzed the role of activity-based learning in the sixth-grade Math classes. The researcher accepted the importance of Mathematics in everyday life. Similar to the studies, the author examined effects of activity-

based learning in increasing student learning rate in Math classes. The study put a great emphasis on the findings of previous studies and concluded that activity-based learning positively affected Math classes. The author designed experimental study with the help of pre-test and post-test focus groups. The main question of the study focused on the relationship between activity-based teaching in class and learning Mathematics. The study mainly targeted sixth grade students and Math instructors. While the experimental group was taught with activity-based learning approach, the control group students had classes in traditional ways. The author revealed that experimental group students were more successful compared to the control group students, which was the indicator of the positive impact of activity-based learning on Mathematics classes.

Another research on the impacts of activity-based learning method in Math classes was conducted by Ozdemir and Altintas (2015). The researchers administered pre-and post-tests involving the seventh graders to understand the efficiency of activity-based learning compared to traditional models. The scores confirmed that the utilized activity-based learning approach had a positive effect on the 7th graders. It was recommended that activities should be designed based on Math curriculum, the effects of implementing ABL should be analyzed via debating with students, and students should be asked about the activities and their learning outcomes (Ozdemir & Altintas, 2015).

International Islamic University in Islamabad, Pakistan is one of the institutions examining the relationship between activity-based learning and the effectiveness of Math classes. The study conducted in the university by Mustafa (2011) involved secondary school teachers and Math students, and it mainly focused on possible effects of activity-based learning method in Math classes. The researchers designed a solution to increase the efficiency of Math classes via

activity-based learning. The review of the study provided strong arguments on how activity-based learning may have helped students learn Mathematics better.

Implementation of real-life activities in math classes has a high potential to boost the effects of activity-based learning approach (Mustafa, 2011). It should be noted that there are several challenges in implementing activity-based learning in Math classes. According to Shamali's research (2018), several challenges such as lacking guidebooks, funding, time, and low-level of training were highlighted. Those challenges were believed to prevent the application of activity-based learning in Mathematics classes.

Activity based learning and its impact on Mathematics as a subject is supported by other researchers. With regard to the impacts, the experiments conducted in Nepal by Pokhrel (2018) helped to understand the efficiency of activity-based math instructions. Using the approach by John Dewey, the study implemented a quantitative analysis.

According to John Dewey (n.d.) approach, Activity Based Mathematics Instruction (ABMI) is guided by the progressive philosophy of education and this approach focuses on learning by doing (Miovska-Spaseva, 2016, p. 215). ABMI is based on activity that involves learners in reading, writing, discussion, practical activities, problem solving, analysis, synthesis, and evaluation (Festus, 2013).

Pokhrel (2018) takes ABMI as the conceptual framework for the analysis and tries to evaluate the effectiveness of learning by doing. According to the study, games are the best way of learning Math with fun while practical activities are skill-oriented approaches (Pokhrel, 2018). The study reveals that implementation of activity-based learning via games, practical activities, math lab and exhibition, and project work leads to increased critical thinking and problem

solving, communication and collaboration, and creativity. The qualitative research method and interpretive research paradigm is mainly implemented within the study, and the research proves that activity-based learning contributes to overall development of students (Guba & Lincoln, 1994).

## Use of the Technology in Mathematics Classes

Integrating technology in education made the application of activity-based learning in Math classes inevitable. Given the importance of integrating technology in Math classes via activity-based learning, Koehler and Mishra (2008) have coined a new term which is a technological pedagogical content knowledge (TPACK). Thus, these practices and pedagogical aspects were combined to improve activity-based learning. The research was accomplished with the participation of students. The results show that one of the successful uses of technology in education is the integration between technological solutions as a part of ABL in Math classes (Fuson, 2005; Kaser, 1999; Reece, 2005). Working with technologies in Math classes not only simplifies students' learning, but also helps them handle multi-tasking, active and creative thinking, and become more comfortable with technologies (Heid, 2005).

As time passes, digital transformation's entrance to education sphere fastens and it leads to the creation and improvement of digital schools. Activity-based learning has been the focus center for digital schools as well to increase the effectivity of learning process. Considering that participating in activities helps to boost students' learning efficiency; researchers started to focus on ABL for digital schools. Radhika (2019) argues that classroom environment, explanation of subject content, participation of students in the learning process, role of educators, and implementation of creativity and resourcefulness are principal factors to consider while implementing activity-based learning at digital schools. Referring to the reviewed literature, the

author suggests that instructors should explain lesson plans and concept via putting activities into operation. At the same time, instructors are expected to encourage student participation for achieving creativity and resourcefulness (Radhika, 2019).

Although the significance of activity-based learning in Mathematics classes has been accepted for many years, there is still a need to analyze differences between traditional methods and activity-based learning. The researchers Noreen and Rana (2019) analyzed various influences of both methods on elementary level Mathematics classes. Fundamentals of Math is taught in elementary schools. Thus, the focus of the study was elementary school students. The researchers designed pre-test and post-test groups with the participation of 120 students. The students were divided into two groups. One of the groups was taught Math using traditional methods and another using ABL techniques. Post tests were necessary for analyzing the effects of ABL techniques in Math classes. The results demonstrated that the students taught with ABL techniques were more successful compared to another group. The study recommends implementing ABL techniques for elementary school Math classes (Noreen & Rana, 2019).

Nigeria is one of the countries suffering from the low-level achievements in Mathematics classes (Festus, 2013). The main cause of this problem is the conventional method of teaching in Mathematics classes. Festus (2013) suggests application of activity -based learning as a solution for learning better in Math classes. Throughout the study, the author examines the ways to strengthen the application of activity-based learning in Mathematics classes and emphasized discovery approach of teaching, appropriate practical work, use of teaching aids, cooperative or small group learning, and discussion in class (Festus, 2013). The author derives cross results with previous examination in the same area. Similarly, Okwudishu (2011) states that self-initiated learning is the best way of actively involving students in learning process. Both Festus

(2013) and Okwudishu (2011) have concluded that activity-based learning is significant for students to learn better in Mathematics classes. According to Okwudishu (2011), activity-based learning supports course content, contributes to students' self-esteem, enables creative problem solving, develops team building skills, and improves participatory and discovery learning.

The positive impacts of activity-based learning in Mathematics classes are strongly defended by not only prior but also recent research. The initial results of Yuksel's (2013) study, which involved children from different countries across the age range of 10-12 years, proved the positive impact of activity-based learning. On the other hand, the study also revealed that students' prior knowledge level and self-regulation skills influenced students' learning when activity-based learning was applied (Yuksel, 2013). The study emphasized the significant role of prior knowledge and self-regulation skills for successful implementation of activity-based learning in Math classes.

Literature review analyzed previous studies critical to the application of activity-based learning approach in Math classes. Several studies discussed throughout the literature review indicated that implementation of activity-based learning in teaching had been the center of focus for years. The studies conducted to explore the effects of ABL specified that this approach had a significant positive impact on increasing the efficiency of learning in classes.

# Chapter 3: Methodology

## Research Method and Design

This research employed a qualitative research design (Denzin & Lincoln, 2018). In fact, qualitative research method is usually applied in humanities, education, health sciences, and history (Saunders, 2012). Being an appropriate type of inquiry, the qualitative research design allowed us to see the participants in their natural settings and gain insight, to explore the depth, richness, and complexity of the phenomenon (Denzin & Lincoln, 2018).

The study includes a set of flexible guidelines that align the constructivist paradigm with the strategies of inquiry and data collection methods (Denzin & Lincoln, 2018). To explore and understand teachers' and students' perceptions about Math classes and activity-based learning, my fellow research practitioner and I utilized interview approach at the first stage (Kvale & Brinkmann, 2009). Semi structured individual interviews were conducted with the participation of Math teachers (Remler & Van Ryzin, 2015; Merriam & Tisdel, 2016). Individual interviews assisted to have more control over the direction of the dialogue between us and four Math teachers (Kvale & Brinkmann, 2009) and generate information about teaching and learning Mathematics and also activity-based learning. Two focus group interviews were administered with the 10th graders as Casey and Kueger (2000) state it is "a more natural environment than that of individual interview because participants are influencing and influenced by others- just as they are in real life" (p.11). Each focus group consisted of three $10^{th}$ graders. Hence, focus group interviews we held aimed at collecting high-quality data in a social context (Patton, 2002) and understanding the specific problem, which is teaching and learning Math and activity- based learning, from the research participants' perspectives, who were the $10^{th}$ graders (Khan & Manderson, 1992).

The second stage of the study was piloting the activities from the Activity Toolbox designed based on the Math teachers' and the 10th graders' perceptions on teaching and learning math and activity-based learning. The math teachers form ADA High School piloted activities for teaching Trigonometric Functions to the 10th graders in the online classes. Then my fellow research practitioner and I observed four recorded sessions and took notes. Then we observed the recorded sessions where Math instructors utilized those activities. Four teachers were interviewed to get their reflection on the taught classes where the students were instructed based on activity-based learning and piloting the activities. After we did observations and interviewed Math instructors for the second time to apply triangulation of the data for testing validity through the convergence of information from different sources. We compared and contrasted the data obtained from the observed Math classes and instructors' interviews. Applying triangulation of the data from two sources assisted to establish credibility and it also contributed to trustworthiness (Dye, J.G, Schatz, I. M., Rosenberg, B. A., & Coleman, S. T.).

Besides the outside expert was asked to review and examine the research process and the data analysis. Using this technique, we ensured that the findings were consistent and could be repeated.

The authors of this study – Mujgan Aliyeva and Nigar Aghayeva are ~~also~~ Math instructors at ADA School. The fact that project members are also Teaching Mathematics and working in ADA School could be subjective in data analysis and have some bias or interest in interpreting the data to better align with own reality or belief. (Morse, J. M., Barrett, M., Mayan, M., Olson, K., Spiers, J., 2002). In order to be maximum objective-during this process, and decrease the chance of having bias, we implemented inquiry audit to establish dependability (Akkerman, S., Admiral, W., Brekelmans, M. and Oost, H., (2006)).

## Sampling

Based on the simple random sampling, which is one of the probability sampling methods (Creswell J. W., 2013; Creswell J. , 2014), out of 236 10th graders of ADA School were divided into six groups studying Mathematics, one participant from each group was chosen. The average age range of 10th graders was between 15 and 16.

Concurrently, four teachers were chosen based on the expert sampling to be interviewed so that we were able to get their perceptions. The average age range of Math teachers teaching the 10th graders at ADA School was between 22-67. As this research focus on an individual's experience and understanding, there is a recommended size, which is at list six participants to be selected (Mertens, 2010).

## Interview Questions

During the piloting phase we interviewed one instructor. Piloting was necessary for our study because of three reasons.

1. To ensure if our interviewees understand our questions and can answer them;
2. To understand if we can manage to collect answers for all questions in the available time for interviews;
3. To ensure that we get all the necessary information needed to the answer research question.

Piloting allowed us to consider online education cases. During the pilot interviews it was noticed that unexpected timing problems may have occurred during online classes and the question regarding the evaluation of timing was added in the list of questions. After pilot

interviews, we recognized additional theme in dataset which was not relevant with our questions. Nevertheless, this new theme led us to two questions in the Teachers' Interview Protocol.

Furthermore, piloting with students also helped us strengthen our interview questions. As the Activity Tool-Box design was based on the student-centered teaching approach, during the analysis of the interview, a new theme was found. After analyzing the pilot interview, that question was also included to the Students' Interview Protocol.

## Data Analysis

Based on the model – "Six Phases of Thematic Analysis" by Braun and Clarke (2006), this study used thematic analysis of transcripts examining what the outcomes of implementing activity-based learning during the Math classes were. The model by Braun and Clarke (2006) focuses on identifying, analyzing, and interpreting patterns of meaning within qualitative data. The process in this study covered phases as mentioned above:

*Table 1: Six Phases of Thematic Analysis by (Braun & Clarke, 2006).*

| Phase | Process | Result |
|---|---|---|
| Phase 1 | Read data to become familiar with its details. | Start initial coding and taking notes. |
| Phase 2 | Generate initial codes and note where patterns occur. | Comprehensively code to show how data answers research questions. |
| Phase 3 | Combine code into overarching themes. Developing themes are also considered. | List candidate themes for further analysis. |
| Phase 4 | Analysis of how themes support data and theoretical perspective. If the analysis | Accurately understand how themes are patterned to tell a story about the data. |

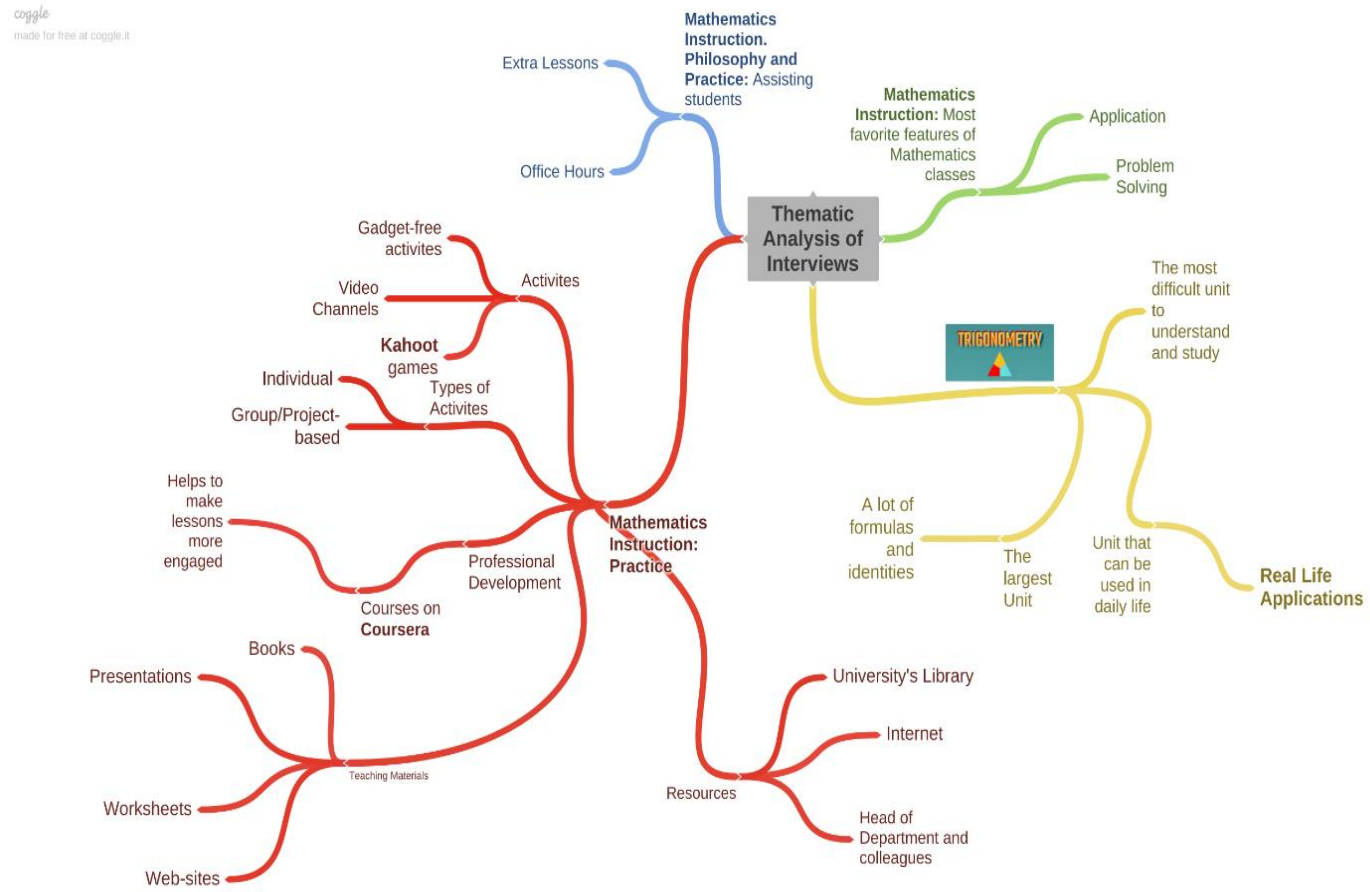
| | | |
|---|---|---|
| | seems incomplete, go to previous phases. | |
| Phase 5 | Define themes accurately, aspects of data captured, and interesting facts about the themes. | Detailed analysis of how themes contribute to understanding the data. |
| Phase 6 | Make decisions about which themes make meaningful contributions to understanding the data. If necessary, go back to sample for checking if the description is an accurate representation. | Develop a thick description of the results. |

Mapping of instructors' interview results show that four main themes were noticed during thematic data analysis. These themes are Mathematic Instructions: most favorite features of Mathematics classes, Practice, Mathematics Instructions: Philosophy and Practice – Assisting students and Trigonometry.

Analysis of the interview data show that there are two favorite features in Mathematics classes which are application and problem solving. On the other hand, instructors assist students via extra lessons and during the office hours. The activities in Math classes mostly include gadget-free activities, video-channels, and Kahoot games. These activities are done in both

individual and group-work formats. These activities and practices lead to personal development of students and increases engagement in lessons. The interviews also reveal that during math classes, books, presentations, worksheets, and web sites are the primary teaching materials. ADA University's library, Internet, and the head of Mathematics department and colleagues are the main resources for learning according to the interview data.

*Figure 1: Interview Questions Mapping*



## Chapter 4: Major Findings of Study

The interviews conducted after the implementation of activity-based learning demonstrated that instructions were clear and understandable. The instruction Checking Questions (ICQ) were designed to test if students clearly understood the instructions for ABL. On the other hand, it should be noted there was a problem regarding the timing. Since the activities were applied in online classes, extra five minutes were added for each activity. Based on the students' feedback, it should be noted that activity-based learning approach was successfully applied and it made students enthusiastic in solving math problems.

The focus of the study was piloting Activity Toolbox. The piloted activities were designed the way that they promoted activity-based learning approach. The positive impact of activity-based learning in complex subject like Trigonometry was noticeable. Initially, students thought that it would be difficult to learn with activity-based learning approach. Nevertheless, their interest started to increase during the classes and they understood the topic easily. Trigonometry is a complex topic in Math. Anticipating the issue, we expected to face difficulties during the activities as students could easily get confused due to the complexity of the topic and instructions of the activity. Nevertheless, since ICQ helped students understand the instructions, ABL approach made learning easier than expected.

In this study, the Activity Toolbox was designed and tested through activity-based learning approach. Based on the results of focus group interviews with the tenth graders and individual interviews with the Math teachers, we considered students' interests and skills as well as teachers' perceptions while developing the Activity Toolbox. These considerations contributed to achieve positive results in piloting activities from the Activity Toolbox during Math classes. Moreover, we also requested teachers to provide us with students' feedback to

understand if there were any problems in the design of activities. According to teachers, students' feedbacks were mainly positive regarding the implementation of ABL in Math class using activities from the Toolbox (see Figure 7).

*Figure 2: Interview Results Mapping*

## Discussion

The purpose of the Capstone Project was to explore students' and instructors' perceptions about teaching and learning math, design and pilot design an Activity Toolbox which may have increased the learning efficiency of students during Math classes. The piloting interview increased the reliability of interview questions. Both students and instructors were interviewed before implementation of Activity Toolbox. After implementing activities during the classes, the instructors were interviewed again. Using thematic analysis of qualitative data, study revealed that activity-based learning may have had a positive impact on the efficiency of math classes at high schools.

### Interpretations

The major finding of the Capstone Project was that ABL may have positively affected the tenth graders' Math learning at ADA School based on the results of observations and Math teachers' post- piloting interviews. The study allowed to conclude that Instructions Checking Questions helped students easily handle understanding instructions of ABL and the Trigonometric functions unit taught during the observed classes where activities from Toolbox were utilized.

### Implications

Effective teaching focuses on the efficiency of students' learning during the class. Most of the classes fail achieving this goal. The main reason behind this challenge is the traditional passive learning approach implemented in classes. At ADA School it was noticed that Math was taught using conventional approaches and it was not successful to teach Trigonometric functions based on this. Students were not excited and interested in studying it.

The implementation of ABL at high school math classes indicated that this approach has

a potential to increase motivation of students, their engagement during the class, and the rate of understanding the topic. Although ABL is mostly applicable for in-class system, it is also suitable in online teaching and learning. Schools should consider the importance of ABL in classes and take action to achieve high level of ABL implementation for both in-class and online.

## Limitations

One of the limitations of this study is the selection of sample. The sample includes teachers and students of ADA School. This limitation may lead to the sample or selection bias.

It should be noted that during the time that the Capstone Project was carried out limited schools were available for conducting it. Given the availability of high schools, only ADA School agreed on contributing to the project. Being limited to one school, it was not possible to provide more detailed analysis where genders, ages, and grade level of the students could be analyzed, and the study could provide more accurate data and the results may have changed based on those factors.

The capstone project was limited in time, schools from other geographic area, and sample size. Nevertheless, limited time urges the necessity of further studies considering students and teachers from different schools of Baku and other regions of the Azerbaijan Republic.

# Chapter 5: Final Product

**Activity 1**

**Grade Level**-10th grade

Unit: Trigonometric identities

Topic- Trigonometric identities

**Required Materials/ Equipment:**

Worksheet1 with the previous topic's notes for helping in warm-up activity; Worksheet2 with activity on it; Ppt/Smart board; Whiteboard.

**Anticipated Problems**

Students might forget the trigonometric formulas

**Solutions**

Use warm-up activity as repeating previous topics in order to work on new topic more effectively.

Modeling of activity:

**Puzzle Activity**

Forming group of 4-5 people by just changing their places (different people from warm-up activity groups). Giving pieces of paper and asking: "Please, take them, but not open yet. This is the pieces of puzzle. You should solve the problems, and then match them by choosing the ones who have the same answer. The team, (not group! Because they have common purpose) who will finish matching puzzle first, will be the winner. And, please, do not forget that your participation during the class is graded!"

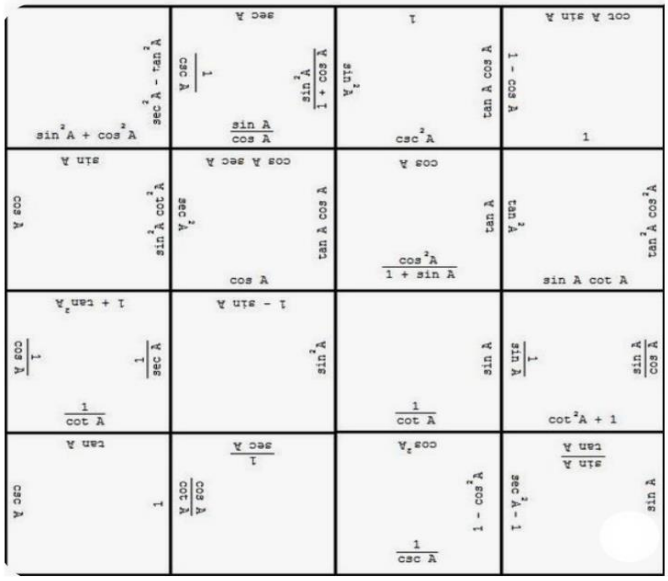
ICQ: "X, can you explain what you are supposed to do?"

**Time**

6-7 min

**Comments**

On-going feedback to teams.



**Activity 2**

**Grade Level-**$10^{th}$ grade

Unit: Trigonometric identities

Topic- Trigonometric identities

**Required Materials/ Equipment:**

Worksheet with the previous topic's notes for helping in warm-up activity; Flip Chart with activity; PPT;Smart board;Whiteboard.

**Anticipated Problems**

Students might forget the trigonometric formulas

**Solutions**

Use warm-up activity as repeating previous topics in order to work on new topic more effectively.

Modeling of activity:

**Gallery Walk Activity**

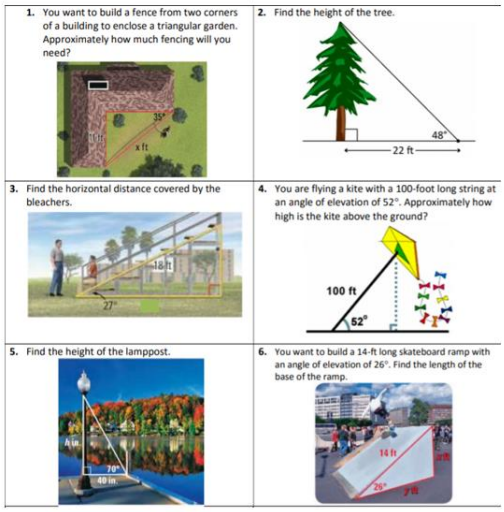
Forming group of 4-5 people with the help of group generator. Teacher will place all of the problems around the room in order. Each group of students should have a blank answer sheet. Students will start on any problem. Students will complete the problem in the correct box and write the answer in the blank.

**Time**

10 min

**Comments**

On-going feedback to teams




| | |
|---|---|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |

**Activity 3**

**Grade Level**-10th grade

Topic- Trigonometric identities

**Required Materials/ Equipment:**

Worksheet1 with the previous topic's notes for helping in warm-up activity; Worksheet2 with activity on it; Ppt/Smart board; Whiteboard.

**Anticipated Problems**

Students might forget the trigonometric formulas

**Solutions**

Use warm-up activity as repeating previous topics in order to work on new topic more effectively.

Modeling of activity:

**Trig Identity Find It!**

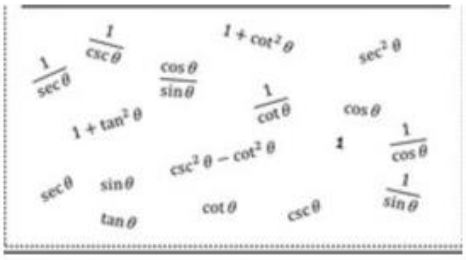
Forming group of two with the help of random sampling. Print out game and make enough copies so that every two will have a copy. Teacher calls out part of a trigonometric identities and students finds its match (what is equal to). If the expression 1/cos, then the student will look for sec. The first group to find and circle the answer gets a point. Play until all expressions have been used up or a certain time limit.

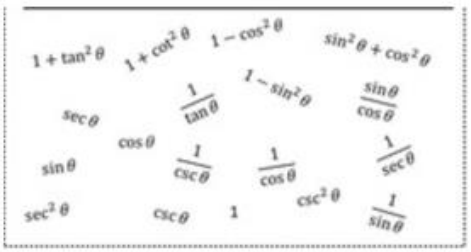
**Time**

6-7 min

**Comments**

On-going feedback to groups



**Activity 4**

**Grade Level-**10th grade

Unit: Trigonometric identities

Topic- Trigonometric identities

**Required Materials/ Equipment:**

Worksheet1 with the previous topic's notes for helping in warm-up activity; Worksheet2 with activity on it; Ppt/Smart board; Whiteboard.

**Anticipated Problems**

Students might forget the trigonometric formulas

**Solutions**

Use warm-up activity as repeating previous topics in order to work on new topic more effectively.

Modeling of activity:

**Creating Graphs of Sine, Cosine, and Tangent from a Unit Circle**

Forming group of 4-5 people by just changing their places (different people from warm-up activity groups).

This non-calculator activity will engage the students in creating the graphs for y = sin r,

y = cos r and y = tan r from the unit circle for values of $0 \leq r \leq 2\pi$.

• To graph the function y = sin r students are given a unit circle (divided into sixteen parts to match with π/6, π/3, π/4, π/2, etc) adjacent to an rx plane. Using the value of r and the x coordinate for each point on the unit circle, students create a graph of thirteen points on y = sin r. They are then asked to draw a smooth curve through the thirteen points.

• To graph the function y = cos r students are given a unit circle (divided into sixteen parts to match with π/6, π/3, π/4, π/2, etc) adjacent to an rx plane. Using the value of r and the y coordinate for each point on the unit circle, students create a graph of thirteen points on y = cos r. They are then asked to draw a smooth curve through the thirteen points.

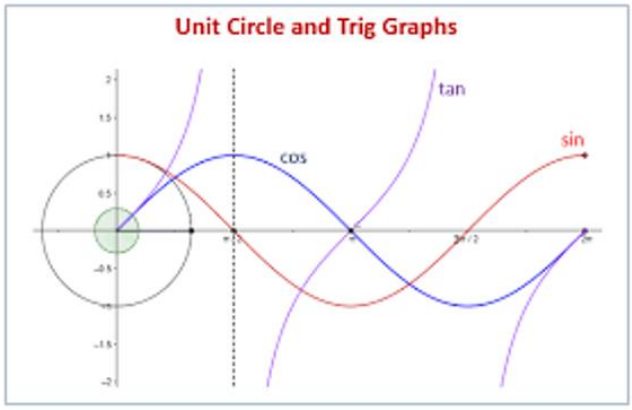
• To graph the function y = tan r students are given a unit circle (divided into sixteen parts to match with π/6, π/3, π/4, π/2, etc) adjacent to an rx plane. Using the value of r and the quotient of the y coordinate and the x coordinate for each point on the unit circle, students create a graph of thirteen points on y = tan r. They are then asked to draw a smooth curve through the thirteen points. Students observe that this graph is not a continuous graph. There is asymptotic behavior at π/2 and 3π/2.

**Time**

9 min

**Comments**

On-going feedback to teams.



**Activity 5**

**Grade Level-**10th grade

Unit: Trigonometric identities

Topic- Trigonometric identities

**Required Materials/ Equipment:**

Worksheet1 with the previous topic's notes for helping in warm-up activity; Worksheet2 with activity on it; Ppt/Smart board; Whiteboard.

**Anticipated Problems**

Students might forget the trigonometric formulas

**Solutions**

Use warm-up activity as repeating previous topics in order to work on new topic more effectively.

Modeling of activity:

**Inverse Trigonometric Differentiation Task Cards**

These 36 cards are in six sets of six cards. Each of the six sets focuses on an application of using the derivative of inverse trigonometric functions.

- In set 1 the students rewrite the function using the meaning of an inverse function. Then they use implicit differentiation to find dy/dx. They leave their answer as a function of y.
- In set 2 the students find the slope of the tangent line to the graph of an inverse trigonometric function at a point.
- In set 3 the students find the instantaneous rate of change of an inverse trigonometric function at a given point.
- In set 4 the students find dy/dx if y = f(x) by rewriting the equation using the inverse trigonometric function.
- In set 6 the students find the instantaneous rate of change of an inverse trigonometric function y=f-1(x) at a given point.
- In set 7 the students find the equation of the tangent line to the graph y = f-1(x), an inverse trigonometric function at a given point.

These cards show the students a different approach to finding the derivative of an inverse trigonometric function. Instead of just memorizing a formula for derivative of inverse functions, students are encouraged to rewrite the functions without using the inverse functions and then use implicit differentiation to find the needed derivatives.

The basic procedures are developed in the first set of six cards (white cards). With these cards students find the derivative of the six basic inverse trigonometric functions. In addition, students are encouraged to leave their derivatives as functions of y. Most of the time in real problems students are asked to find the slope of a function at a specific point so students would know the x and y value. These values can be used to find the derivative.

There are several ways you can differentiate the lesson with these task cards.

- It is probably not necessary for each student to solve all 36 problems. One way would be to have students work in groups of six. They might differentiate one problem each and then compare their solutions with each other and notice the patterns in their derivatives.
- If smaller groups are used, a smaller group of students would work on one or two cards each and then compare their solutions.
- Form six groups and give each group one card from each set. Have each group solve the problems on the seven cards and then make a visual presentation to the other groups on their solutions to the seven cards. Each group can then critique the other group reports.

**Time**

10 min

**Comments**

On-going feedback to teams.

**Activity 6**

**Grade Level-**$10^{th}$ grade

Unit: Trigonometric identities

Topic- Trigonometric identities

**Required Materials/ Equipment:**

Worksheet1 with the previous topic's notes for helping in warm-up activity; Worksheet2 with activity on it; Ppt/Smart board; Whiteboard.

**Anticipated Problems**

Students might forget the trigonometric formulas.

**Solutions**

Use warm-up activity as repeating previous topics in order to work on new topic more effectively.

Modeling of activity:

**Graphic Organizer for Solving Related Rate Exercises (add numbers inside organizer)**

Graphic organizers can help students gather the required information to solve a problem. In calculus students work with problems where various rates of change are taking place in one problem. This package contains one graphic organizer to use when working with related rate exercises.

The graphic organizer is divided into five sections.

• The student should try to draw a picture or sketch to help show a relationship among all the variables in the problem. The student should include any appropriate variables and constants to their sketch.

• In the next section the students should identify which measurements are constants and which are variables. They should also identify all rates of change described in the problem and those that need to be found.

• Now the students should look for an equation that relates the variables and constants. Many times, an area formula, the Pythagorean Theorem, a trigonometric ratio and volume formula might be appropriate to use.

• The student should look at their list of constants and variables and notice which of these change with respect to time and which are constants. The student should take their equation and differentiate it implicitly with respect to time to create a related rates equation.

• Using substitution the student should take their related rates equation and solve for the missing information.

The package includes examples for using each graphic organizer.

# Chapter 6: Conclusion

There are two main approaches implemented in Math classes, which are passive and active earning. While passive learning is proven to bring to undesired outcomes, active learning is one of the best solutions to increase the efficiency of learning in Math classes. After the analysis of literature review, study conducted a qualitative analysis to design and pilot an Activity Toolbox to increase the efficiency of learning in Math classes. The qualitative analysis included the thematic analysis of interviews with teachers. With the participation of total five teachers and seven students, study revealed that ABL may have increased motivation and engagement of students and assisted to comprehend the subject easily.

## Recommendations

The first recommendation for further studies is considering a large sample size. Participation of more-students and instructors from different schools will contribute to the academic context significantly. In this way, it will be possible to analyze the whole population and develop stronger conclusions. The next recommendation is analyzing environmental variables and prolonging the research period to explore the effects of ABL on high school Math classes.

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## Appendix A. Teachers Interview Protocol

Personal Information:

1. How many years are you teaching?
2. What made you become a Math teacher?

Mathematics Instruction: Philosophy and Practice:

1. Can you briefly describe your general approach to teaching math?
2. How do you assist students who need extra help during the class time?

Mathematics Instruction: Practice

The next few questions are dealing with on in math education today, what you think of them, and what influences your math instruction.

1. What teaching materials do you generally use when you teach math? Name three of them.
2. What activities do you use while teaching math? Name three of them.
3. Are you searching for new type of activities? If yes, name three of them. What three criteria do you consider while choosing those activities for your class?
4. Are you using some real-life application activities? If yes, name three of them. What is the reason or rational for using such activities?
5. Do you have professional development opportunities related to math instructions? If yes, how do these professional development opportunities enhance your teaching math?
6. Do you have access to people or resources that can help you with your math instructions? If yes, who are they or what resources you have access to? What else would help you improve your math instruction?
7. Is there anything else that we have not covered yet?

## Appendix B. Student Interview Protocol

Personal Information:

1. Can you please tell me a little bit about your background as a learner?
2. Do you like math? If yes, name three reasons.
3. What is the easiest way for you to learn math?

Mathematics Instruction:

1. What do you like most in math classes?
2. Do you do activities that you can apply in your today or future life? If yes, be specific and name three of them.
3. Do you prefer to work individually or in small groups? If yes, name three reasons.

## Appendix C. Teachers Post-Interview Protocol

Mathematics Instruction: Practice

1. What activities from the Tool Box did you use in your online Math class?
2. At which stage of your class did you use those activities? (at the beginning, in the middle or at the end)
3. Were the instructions clear and understandable for you and students? If not, how should the instructions be improved?
4. Was timing appropriate? If not, how much time is needed?
5. Do you think the activity/s went well? If yes, be specific. If not, why?
6. Were the students engaged in learning Trigonometric Functions while doing those activities? If yes, provide some details of their engagement. If not, what three reasons might be.
7. Do you think that students could comprehend Trigonometric Functions while doing those activities? If so, how did you know that?
8. Did the students reflect on Activity-Based Learning after used activities? If yes, what were their impressions?
9. Is there anything else that we have not covered yet?