Active Learning ArtMath Project in College Algebra Classes

Elizabeth Lugosi

Department of Mathematics, The University of Arizona, USA; elugosi@math.arizona.edu

Abstract

The ArtMath Collaborative Project was an additional Active Learning activity in college algebra classes at The University of Arizona in the fall 2018 semester. The project was developed in collaboration with The University of Arizona School of Art. This workshop will demonstrate the different tasks that students had to accomplish during the semester. Participants will have an overview of student accomplishments throughout the semester. This workshop will empower participants to be able to accomplish similar projects that facilitate students' engagement during group-work, stimulate thinking about the material, encourage discussion, and provide motivation. Participants will also discuss and summarize those goals of higher education that can be achieved through a project like this one.

Introduction

I teach college algebra at The University of Arizona for freshmen students. Before I started teaching this course, I was asked what could be done to increase the passing rate of students. My idea was to encourage students to work together in groups with their peers on problems, discuss certain topics, and present the solution of their team to the class; thus, enhancing students' performance by engagement in different types of activities. Since this idea was well received, I applied it in my classes. Based on this basic concept, I have developed my active learning strategies (Figure 1).

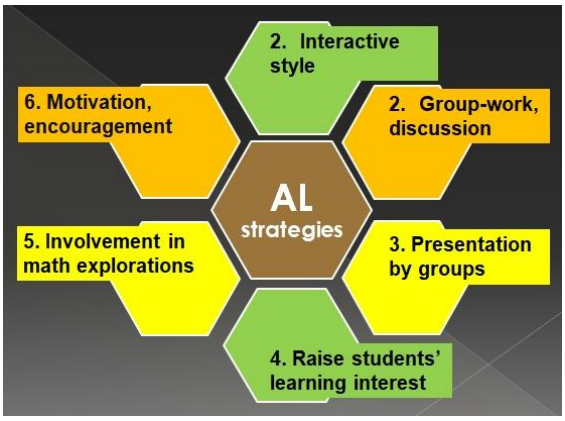

Figure 1: *Active Learning strategies*

The six active learning strategies that I have been using in my undergraduate college algebra and business calculus courses at The University of Arizona [10] are the following:

AL 1. interactive presentation style,
AL 2. group-work with discussion and feedback,
AL 3. presentation of solutions by groups,
AL 4. raise students' learning interest towards specific topics by connecting it to other disciplines,
AL 5. involve students in mathematical explorations, experiments, and math-projects,
AL 6. continuous motivation and engagement of students.

Background

Important goals of undergraduate mathematics education

I consider it important to understand the goals that we aim to achieve in undergraduate mathematics education. Based on the result of literature research, and based on my own experiences, I list here some of the many goals that researchers consider important. This is not a complete list of goals and I have selected specifically these ones, because I have found that the application of the active learning strategies summarized in Figure 1, and the accomplishment of the ArtMath project contributes on a high level to the achievement of these specific goals.

Most of the researchers agree, that important goal of education should be to increase the activity of students when acquiring the material, that is increase student participation during classes, decrease their passivity [1], [3]. One basic activity that teachers can offer is to engage students in an investigation of a certain topic which also provides an opportunity for a discussion and for clarification, [1], [4], [11] and improves the understanding of the material. Using images shown in Figure 2 and 3, for instance, helps the understanding of abstract mathematical terms like transformations, functions. Increasing student performance [6] is also an essential goal, as well as "teach students how to make better decisions", as Professor Carl Wieman, Nobel-Prize winner physicist worded it [15]. In order to help students to store the acquired knowledge in their memory, we also need to provide opportunities for elaborative rehearsal [9], [14]. Especially nowadays, it is more and more important to help students to develop sought-after skills that employers value the most [1], [12], such as the capability of solving problems, working effectively in a team, and be able to communicate about work-related topics. Connected to this, since mathematics is a basis for many other disciplines, it is essential for teachers to help students to decrease their math anxiety [2], [5]. Finally, one of the most essential goals is to decrease the achievement gap between students from disadvantaged and non-disadvantaged educational backgrounds, between ethnic groups and between different genders [8], [13]. Teachers must provide equity for every student that helps them to decrease the achievement gap, and makes it possible for everyone to achieve good results.

During this interactive session, participants will discuss their perception of these goals of education and add additional ones as they feel it necessary.

Active Learning Strategies

During the workshop, the six active learning strategies summarized in the introduction and shown in Figure 1 will be introduced and demonstrated through examples. However, in my experience, I found that the most difficulty comes with finding the right activities for the strategies AL 4 and AL 5. Therefore, this paper and workshop will have an emphasis on these two strategies with the intention of enabling other teachers to apply them in their classes.

I have found it quite challenging to raise students' learning interest towards specific topics (strategy AL 4). In order to overcome this, I connected specific parts of the material to something other than math – i.e., to something that students would regard as "interesting". Therefore, I have developed exercises that were connected to news articles, to real data available on the Internet, and also to nature by taking pictures with the specific goal of connecting math topics to the photos and using them in my classes. For instance, when teaching transformations, I asked students to figure out what transformations can be recognized on the pictures in Figure 2. Then, I asked them to draw a coordinate system on the photos and find specific graphs that can be obtained from each other using those transformations.

Figure 2: *Photos connected to reflections over the axes*

Talking about the main characteristics of a function, I encouraged them to look at the contour photo of the Santa Catalina Mountains and find out where Mount Kimball could be on the picture in Figure 3. Here again, I encouraged them to draw a coordinate system on the photo, and find points with local extremum and absolute extremum.

Figure 3: *A photo connected to the basic characteristics of a function*

These types of exercises led to small project assignments – all of them belonged to strategy AL 5 – where I encouraged students to take photos in nature and connect some specific topic of the material to their pictures. A submission by a team in my college algebra class took a photo of the A-Mountain in Tucson and developed the following exercise: Find the function that you consider to be the best approximation for the contour of the A-Mountain.

These type of exercises, which were all developed with the intention of making students more interested, more engaged in certain topics, led to a lot larger scale project, the ArtMath project where students were continuously engaged and motivated with a semester-long activity. The ArtMath project definitely satisfies strategy AL 5, "involve students in mathematical explorations and math-projects".

The ArtMath Project

In the Art Math project, we have used s artworks of students of The University of Arizona School of Art. The art students gave permission to use their work in the ArtMath project. The students whose artwork is shown on Figure 4 gave their written consent to use this copy of their artworks in publications, presentation, workshops about the project.

Figure 4: *Artworks of the students of The University of Arizona School of Art.*

Art students developed the artworks as an assignment in an art class [7]. The wallpaper drawings were created in the project called "Constructing a Societal Space". The artworks had to demonstrate either the understanding of the artist on the topic or the understanding of the participants of the situation. The perspective drawings were prepared in the "Impossible scenario" project, where art students had to draw an architectural environment with some impossible situation. Students had to be creative not only regarding the impossible elements of the drawing but regarding the location of the building as well.

The main idea of the ArtMath project was to utilize the common interest of people towards art to make important, and – for some students difficult – topics more enjoyable and easier to understand. My intention was to provide students with an opportunity to discover interesting, beautiful, meaningful things in math, to help them overcome their difficulties, and to facilitate students' understanding of crucial math concepts in a pleasant and engaging way. Moreover, the specific learning objective of the project was to find a connection between the art-works and the topic of linear functions.

The ArtMath project was done by 25 student-teams, (altogether 92 students), each team having three to four members in my two college algebra classes. The tasks of the ArtMath project proved to be engaging and entertaining group work assignments where students enjoyed working together and made lasting connections with each other as well as with mathematics. At the end of the project, I asked students to summarize their opinions, thoughts about the project. Their comments also depict the project as being engaging, interesting, and educational nature. These comments – some of them is shown in Figure 5 – will be shared with the participants during the workshop.

In this workshop, the participants will have the chance to accomplish the tasks that students had to solve throughout the semester. Additionally, it will be demonstrated how active learning strategies were applied to specific tasks. Finally, it will also be discussed what goals could be achieved throughout the different phases of the project.

Plan for the Workshop

In this workshop, we will go through the different assignments that students accomplished during the semester. While solving these tasks, I will encourage the participants to think as freshmen students might think about these questions. After every task, we will have a discussion about the active learning strategies that were applied while accomplishing the given task as well as talk about the specific goals that could be achieved. It will be summarized how students' way of thinking about functions evolves as a consequence of each task and how their appreciation towards art and math develops and improves.

Task 1. I will ask participants to form groups of four, preferably with individuals whom they don't yet know. As an ice-breaker exercise, the teams will be encouraged to choose one artwork from Figure 4 that they would like to work with during the workshop.

The teams will receive copies of the original assignments that the art students had to accomplish in order to produce these artworks, and also, they will get a summary of the topics covered in the college algebra course. I will ask participants to discuss why they have chosen a specific artwork and to list three words that characterize their decision process. I will point out that, during the workshop, we will heavily apply the second active learning strategy, AL 2, "group-work with discussion and feedback".

Task 2. I will encourage participants to think individually about possible ways to draw simple graphs on the artworks in order to show some important characteristics of the art pieces. Then, participants will share their ideas with each other and summarize their recommendations in a team-solution. For each artwork, one group will be asked to present their ideas. After the presentations, we will discuss how the third active learning strategy, AL 3, "presentation of solutions by groups" helps students better understand the material.

Task 3. On the wallpaper drawings, – the top three artworks in Figure 4 – participants will examine how the identical forms are displayed and what function can be obtained by connecting those forms. On the perspective drawings, – the bottom two artworks in Figure 4 – participants will be encouraged to find those lines that intersect in one point. During this assignment, students usually have many questions. Instead of telling them what to do exactly, I prefer to give them hints towards the solution and encourage them to discuss with each other what the next step should be to find the right answer. Thus, this task will be a simple example for AL 1, "interactive presentation style".

Finishing this task, we will have a discussion about the goals that these activities contribute to achieving. The teams will be asked to select a few goals that they think these activities can help to achieve.

Task 4. Teams will be asked to draw lines that can characterize the artwork and come up with ideas on how to describe those lines. After an interactive discussion, we conclude that we need a coordinate system if we want to describe the lines precisely. Here, strategy AL 4, "raise students' learning interest towards specific topics by connecting it to other disciplines" is applied.

Task 5. Teams will be asked to discuss possible ways to draw a coordinate system on the wallpapers and on the perspective drawings. Participants will compare different possibilities and compare the advantages, disadvantages.

Task 6. This task represents a turning point in the project when each group member will be asked to set up the equation for one of the lines that they will then take ownership of. This is the task that makes the participants feel that the project belongs to them. Another team member will check whether the equation is correct, and the group will finalize together the equations of four different lines. This is the activity that

strengthens the group by establishing accountability and developing responsibility towards each other's work and – consequently – towards each other. After completing this task, the teams will find a heightened appreciation towards group activities and will grow to consider presentations an important part of that.

Finishing this is a good opportunity to discuss project goals, and make recommendations for additional important goals achievable through the project.

Task 7. Having the lines on the artworks that the groups constructed, one can ask how two lines can be obtained from each other. This is again an opportunity to share ideas and to gather knowledge about transformations collectively. The type of transformations needed is different for the wallpaper and perspective drawings; therefore, this is an excellent opportunity to ask a team working with a wallpaper drawing to join a group working with perspective drawing and discuss the differences between their projects. Transformations are usually difficult for most of the students of college algebra classes; thus, this is the activity where the AL 6 strategy, "continuous motivation and engagement of students" should be frequently applied.

Task 8. The joint groups will be asked to discuss and then summarize their opinion on the following questions: how working with the artworks made the understanding of math concepts easier, how the different types of artworks made the tasks easier/more difficult for them, how the team-work contributed to the clarification of misconceptions or confusion, what additional activity they can think of applying in order to make the learning process easier and more beneficial. Every group will be asked to share their opinion on one of these questions with the audience.

Task 9. The joint teams will be asked to summarize their findings on the goals. They will make a list of those goals that they consider achievable through a project like this one, and by providing reasoning for that. They will also make a list of the additional important, achievable goals that they recommend to add to the original list of goals.

Task 10. The joint teams will make a poster on their accomplishments using the solutions that they have finalized with team members.

Summary and Conclusion

The intention with the ArtMath Project was to add an engaging Active Learning activity in undergraduate math classes that helps students understand important concepts of the course by connecting those to artworks. The learning outcomes for students include the deep understanding of the importance of lines, and transformations. However, this project resulted in additional important learning outcomes that are usually not included in math courses such as understanding, that math is an important part of our world practically everywhere, that working in a team increases individual achievements as well, that one can ease his/her math anxiety in a team-work, while engaging in discussions and solving problems connected to real life [1], [3], [5].

During the workshop, participating in active learning activities, participants will gain a deep understanding of the importance of active learning in team building, collaboration, communication enhancement. An additional outcome of the workshop is that participants will experience how some important goals of education can be achieved by completing a semester-long project that is not only educational but provides relaxed, friendly environment for studying mathematics due to the connection to art. This workshop will empower participants to accomplish similar projects that facilitate students' engagement during group-work, stimulate thinking about the material, encourage discussion, provide motivation, and increase student performance. In Figure 5, I listed some of the opinions of my students about the project. In the ArtMath project students with different background, different races, different genders, different ages worked together and accomplished the project in high quality.

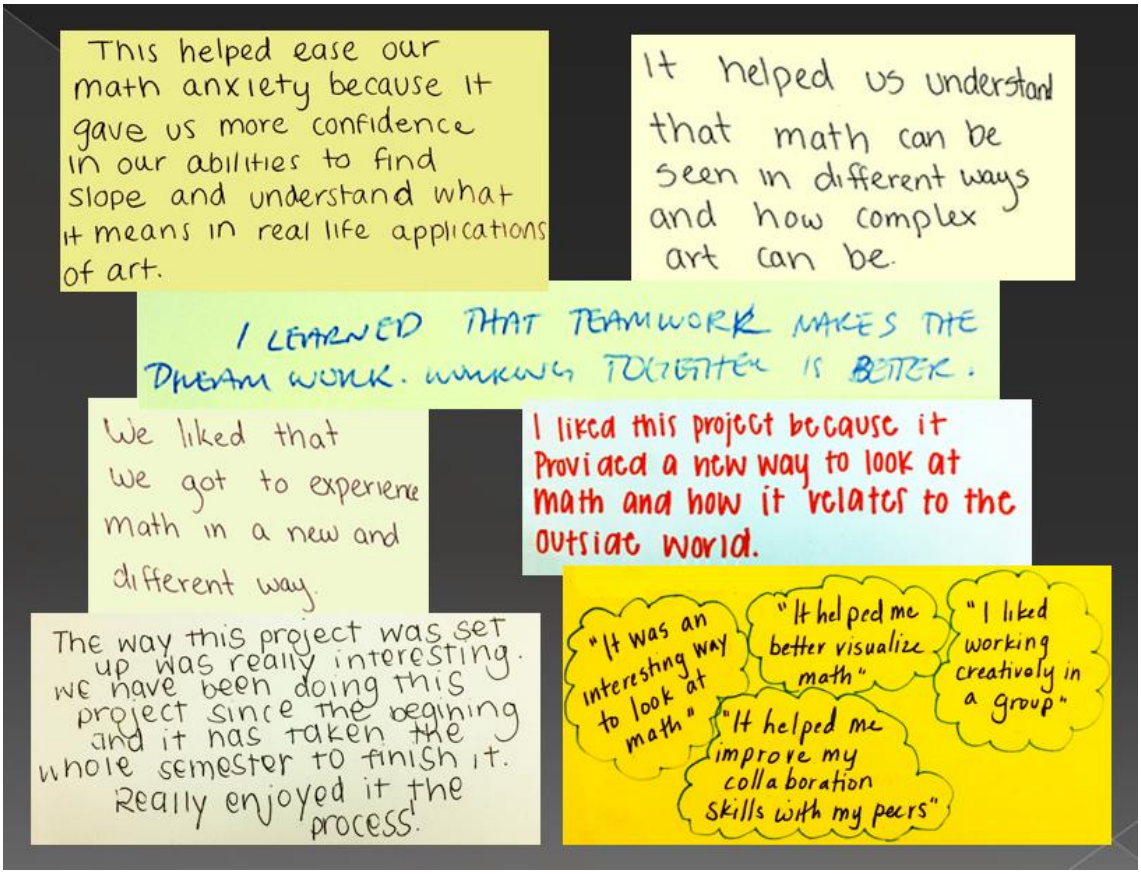

Figure 5: *Student opinions on the ArtMath project*

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