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Explore a real Cartoon Example

Duli Pllana✉

Math Teacher at Jose Marti Stem Academy, BOE, Union City, New Jersey, USA
✉ Corresponding author: dulipllana65@gmail.com

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ABSTRACT

Projects in high school play a significant role in students developing skills with applying mathematical strategies that they learn in real world situations. According to the article, Using Real World - Projects to Help Students Meet High Standards in Education and the Workplace, "Academic rigor - Projects require higher order thinking skills and research methods from academic and technical fields." Math Projects are elementary steps that equip students with basic tools on dealing with research work in the near future. Also, it answers students' popular question during a mathematical session, "where are we going to use mathematical strategies that we are learning in this lesson?" Explore a Real Example is an imaginated case (fiction story - cartoon) that may happen in real life, nonetheless, I improvised the artistic scenario, and conveyed it into the cartoon. When I was a child, my favorite cartoon was Popeye. Therefore, I created Popeye as a main character in the story. Moreover, questions came as a product of nonlinear systems combining with other mathematical topics. Questions in the project require translating the word problem into the mathematical statements; moreover, results will be interpreted analytically and graphically (geometrically).

1 Introduction

The Project explore a Real Example, contains the word problem similar with any real-world scenario. Nonetheless, the text is presented below:

Popeye is sailing with the ship in the Pacific Ocean, and he saw a playful dolphin who is jumping above the sea level. The dolphin jumps in the pattern of circles, and the approximate equation of the circle is $x^2+y^2=16$ *. Popeye has some extra fish, so he decided to feed the dolphin and enjoy the beauty of nature. He throws the fish from the...*

Students are divided into groups of four or five, and they analyze the test carefully with all given information. The teacher does not assist with answers besides explaining the concept of questions. In the beginning the teacher allows students to analyze and lead the research within their groups, as a result, students gain experience in researching in the mathematical field. According to the CMIS: Industrial Mathematics Projects for High School, projects, "allowing students to perform their own research and devise creative solutions can have impressive results" [2]! Students do not have all answers; therefore, they will strive to get the right results. In certain cases, they will not be able to obtain results with the known methods. They will look for alternative ways for solutions, hence, they will encounter slightly different methods. The new methods belong into the domain of creativity.

In the last week before the project is due, the teacher provides more clues how to complete the work. Students have a chance to analyze their mistakes and their positive answers. Based on the article, *Challenges of a New Century, it states,* "Each project has based its work on findings from contemporary research on mathematics teaching and learning and on thoughtful analysis of mathematics" [3]. This project's purpose is to solve nonlinear systems, find relationships between circle and polynomial functions, applying other mathematical strategies etc. By the end of the project the teacher shares answers with the class, and they discuss the benefits of the project.

The first slide contains all the information of the project including word examples and the questions that are asking to respond. The rest of the slides correspond to the question that is asking in the first slide. The last slide asks students to write a paragraph

about what they learned after they answered all questions. The slides bellow from 1 to 14, describe the answers on the given questions of the project # 2. Nonetheless, students' answers might be slightly different answers in the perspective of solving methods and structure of the power point slides. Above all, the analytical result must be the same regardless of the mathematical methods they use.

2 Method

The project is a reflection of a real-world example on a description of cartoon story that incorporates several questions related to geometrical figures and mathematical equations. Questions checks student's understanding on mathematical techniques on the chapter two and three of algebra 2, respectively regular precalculus in the high school. The project is distinctive (original – created by the author/math teacher) contains questions and answers as follows.

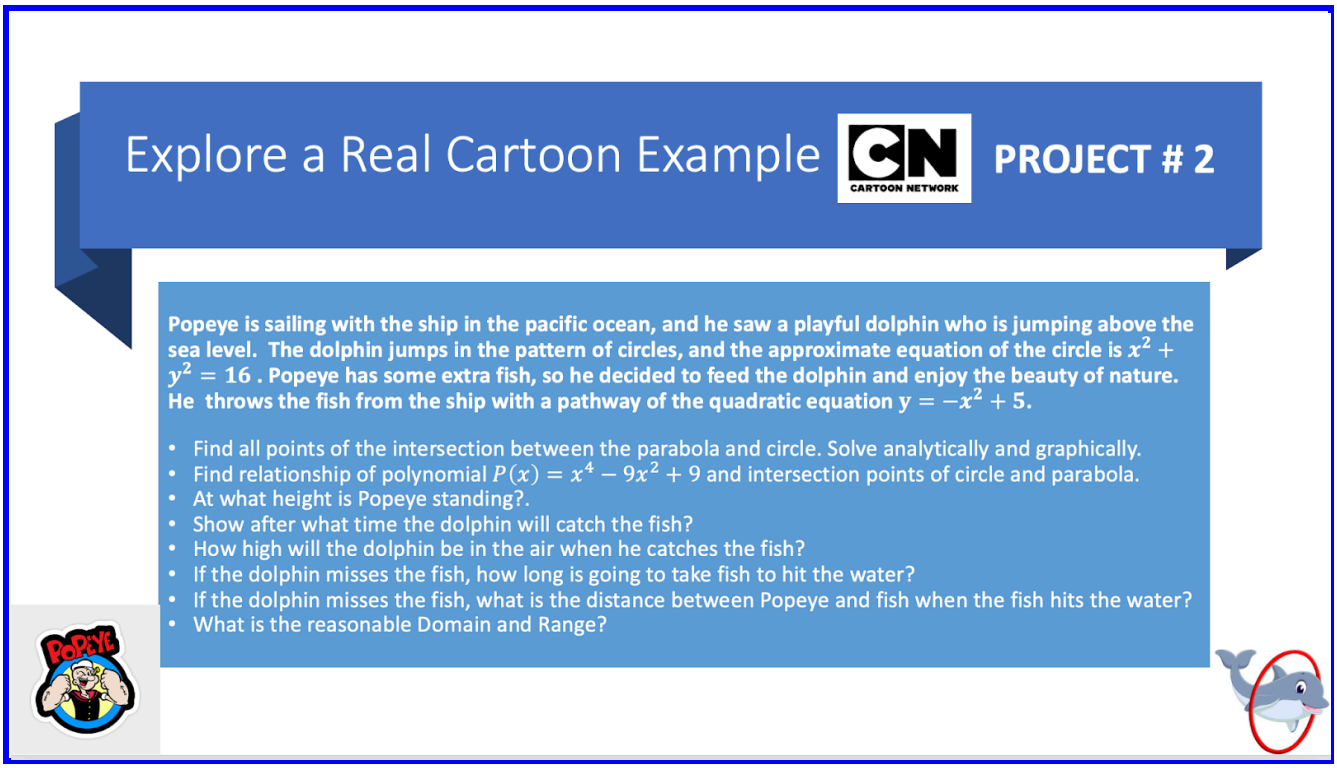

Figure. 1. [4] [18] The project given with the word example from a real cartoon scenario with the given questions.

Figure 2. [4] [18] Popeye is sailing in the ocean when he meets the playful dolphin who is jumping out and in the water by forming a circular pathway. Popeye loves the game of the dolphin, so he interacts with the dolphin by feeding him with the fish.

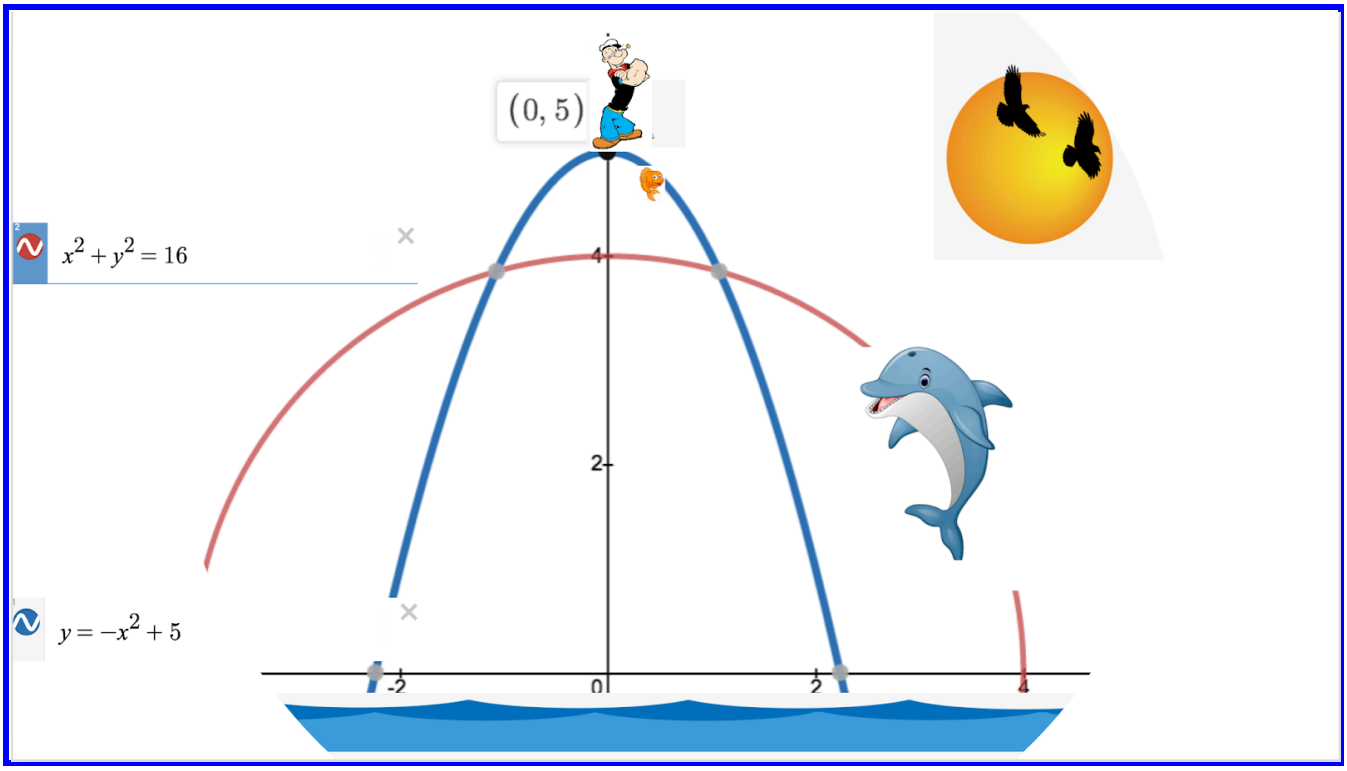

Figure 3. [4]]18] The general information of the real cartoon example is translated into mathematical statements. The figure presents the graphical (geometrical) and analytical interpretation.

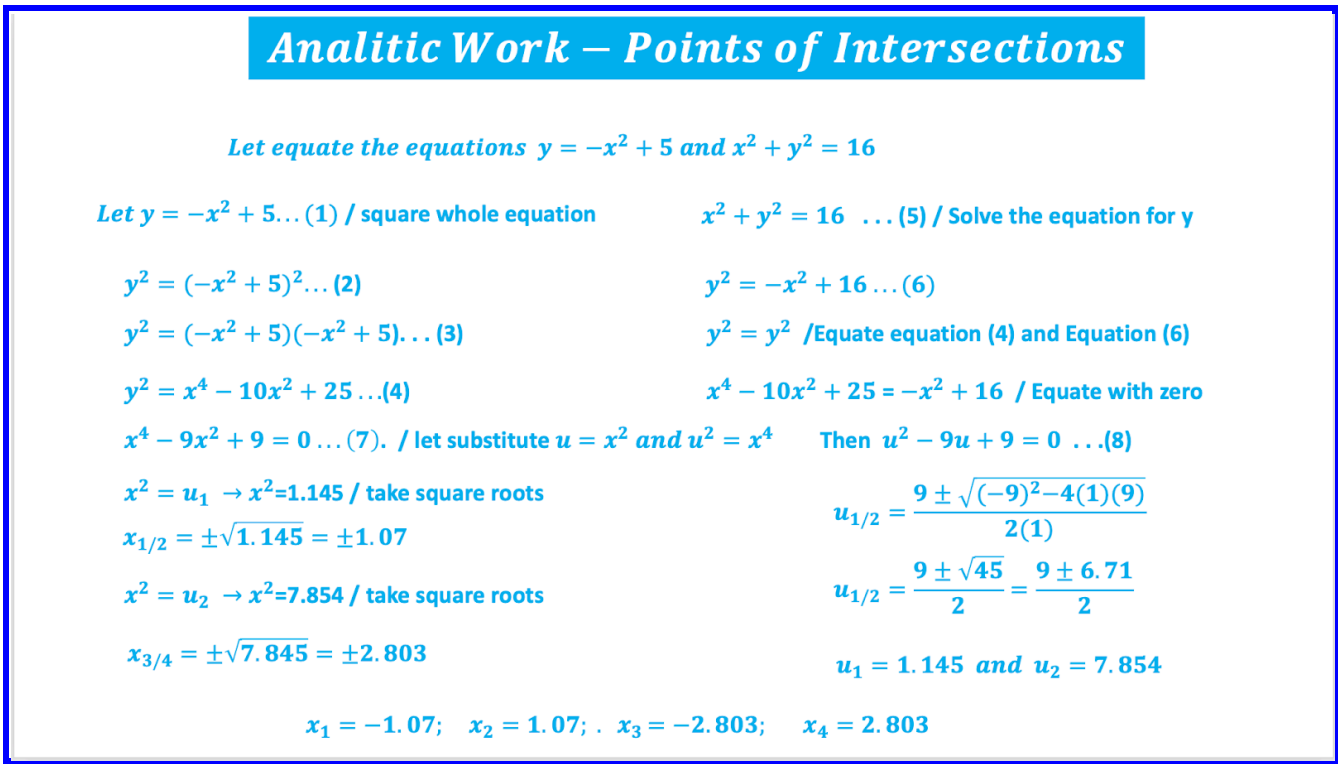

Figure 4. Application of the nonlinear equations of systems can be solved in different methods, nonetheless in this project we used equation y^2 = y^2 by combining equations (6) and (2). Moreover, we found all x - coordinates of points of intersections.

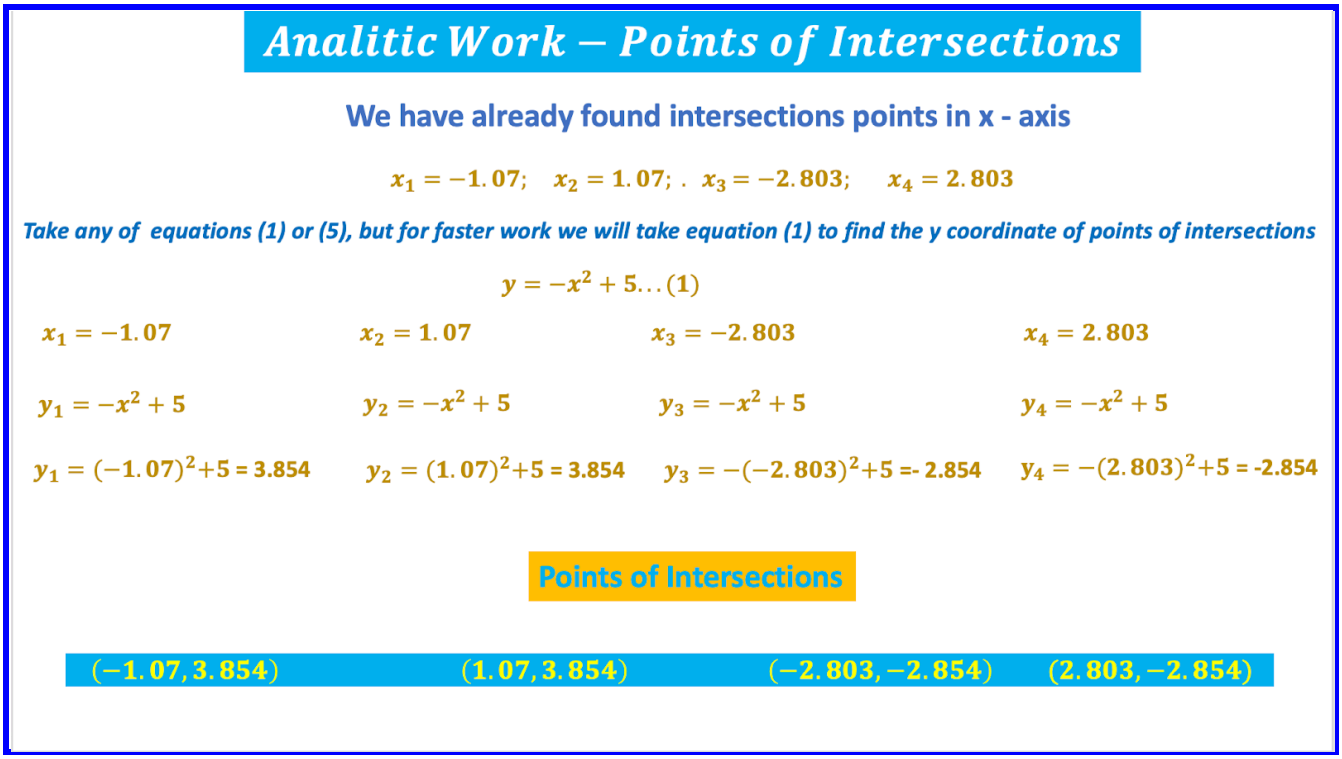

Figure 5. We have already found the intersections point of x- axis and plug them in any equation of circle or parabola. We chose the equation of the parabola because it is much easy to calculate and find y - coordinates intersected points. Then, it completes work on finding the points of intersections.

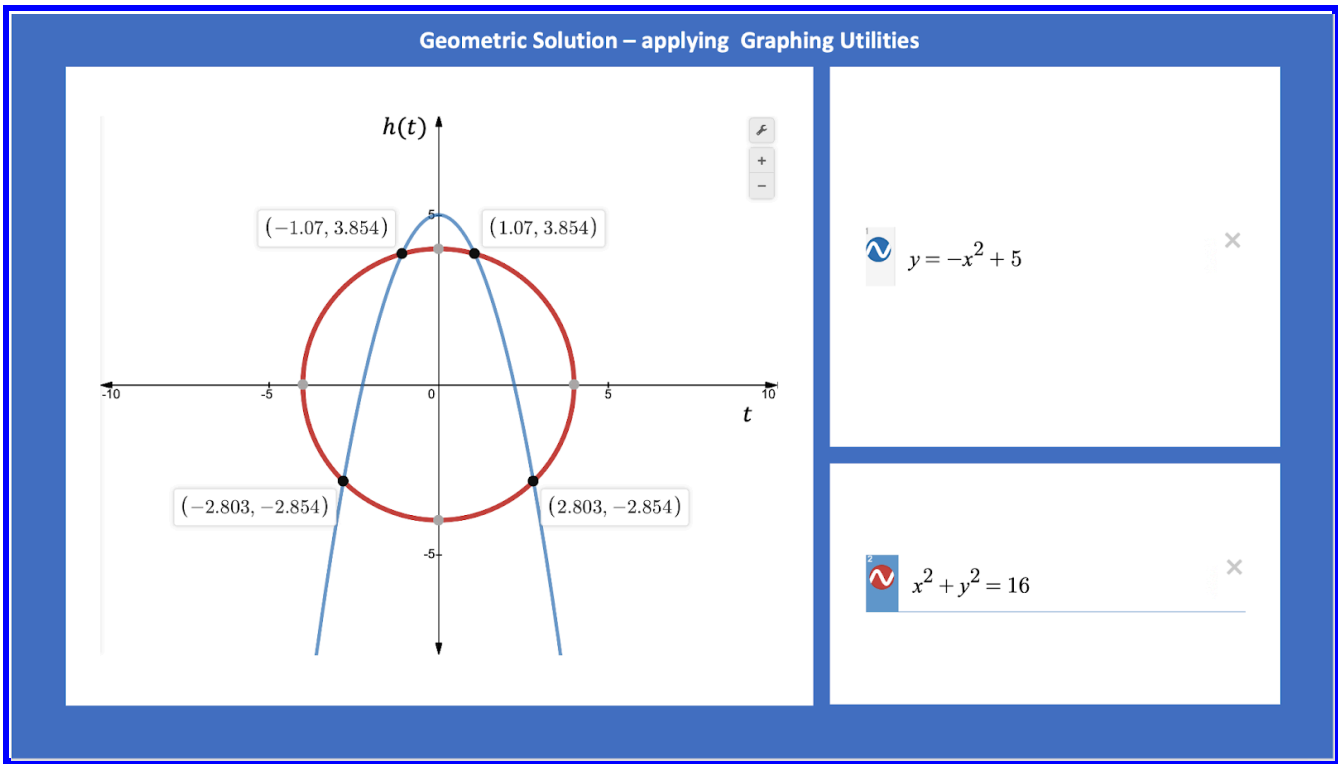

Figure 6. Presents the geometrical respectively graphical solution of the nonlinear systems. In other words, the figure presents visually points of intersection of the circle and parabola.

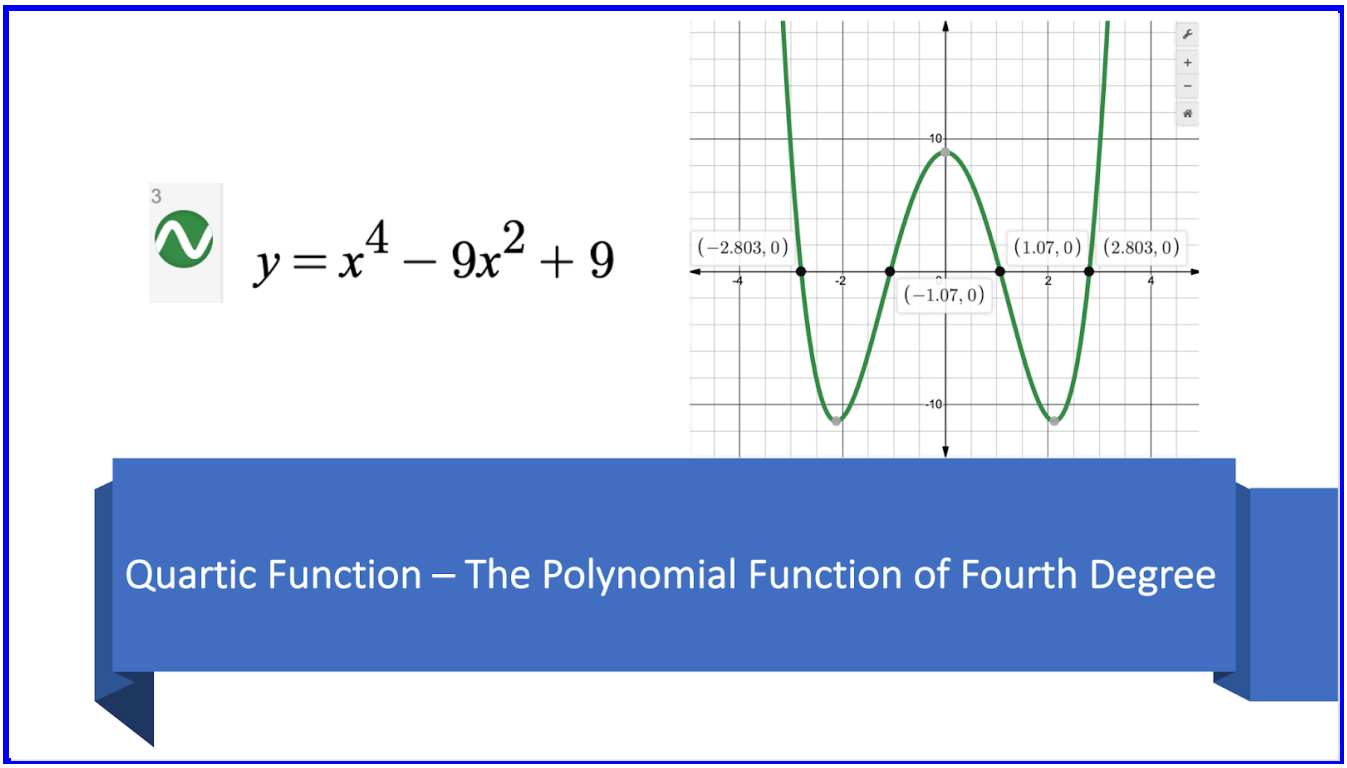

Figure 7. Equation (7) in the Figure 6 represents quartic polynomial function, which graph is dissimilar with the graph of the circle or parabola. Nevertheless, parabola and quartic polynomial function have leading coefficient positive and they are even degree.

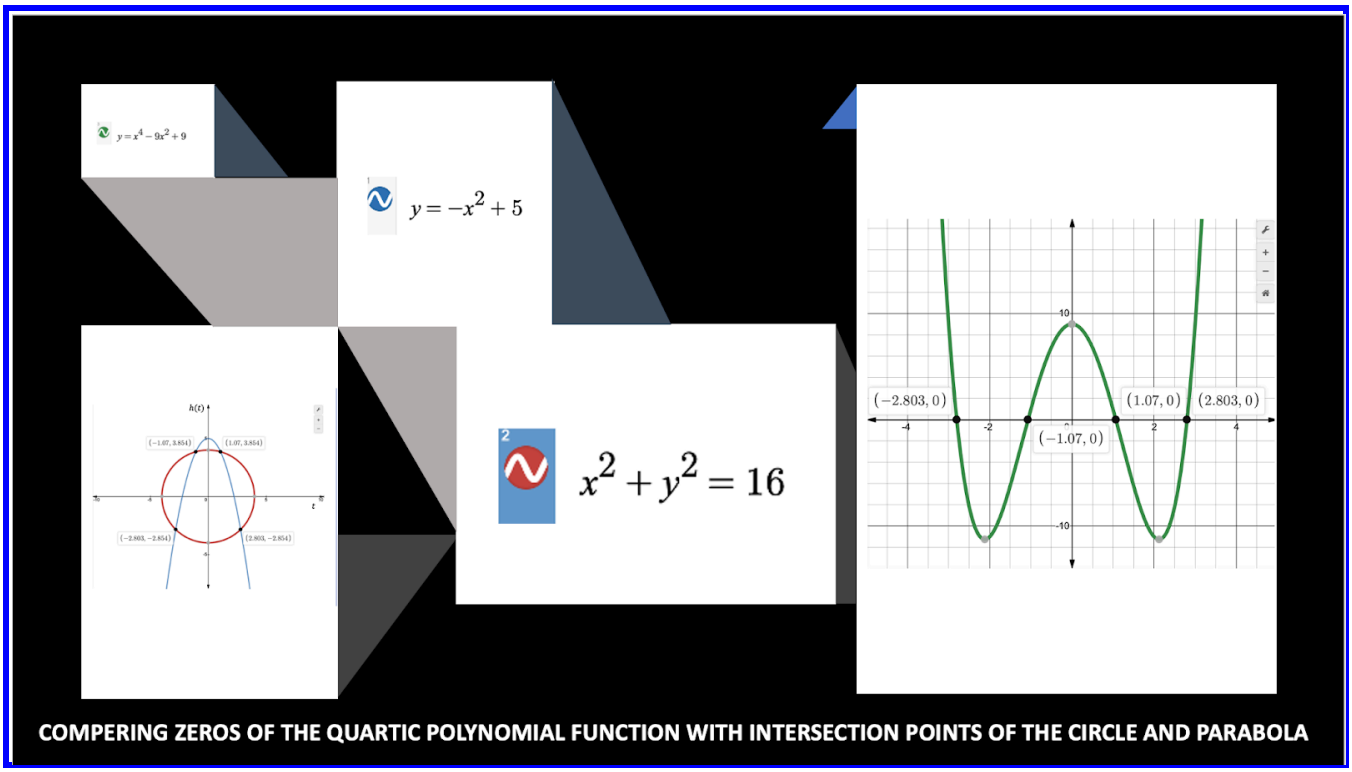

Figure 8. Despite the fact that the intersection graph of parabola and circle are different with the graph of the quartic polynomial function, they still share the same elements. Zeroes of the quartic polynomial functions and x - coordinate of intersection points are exactly the same.

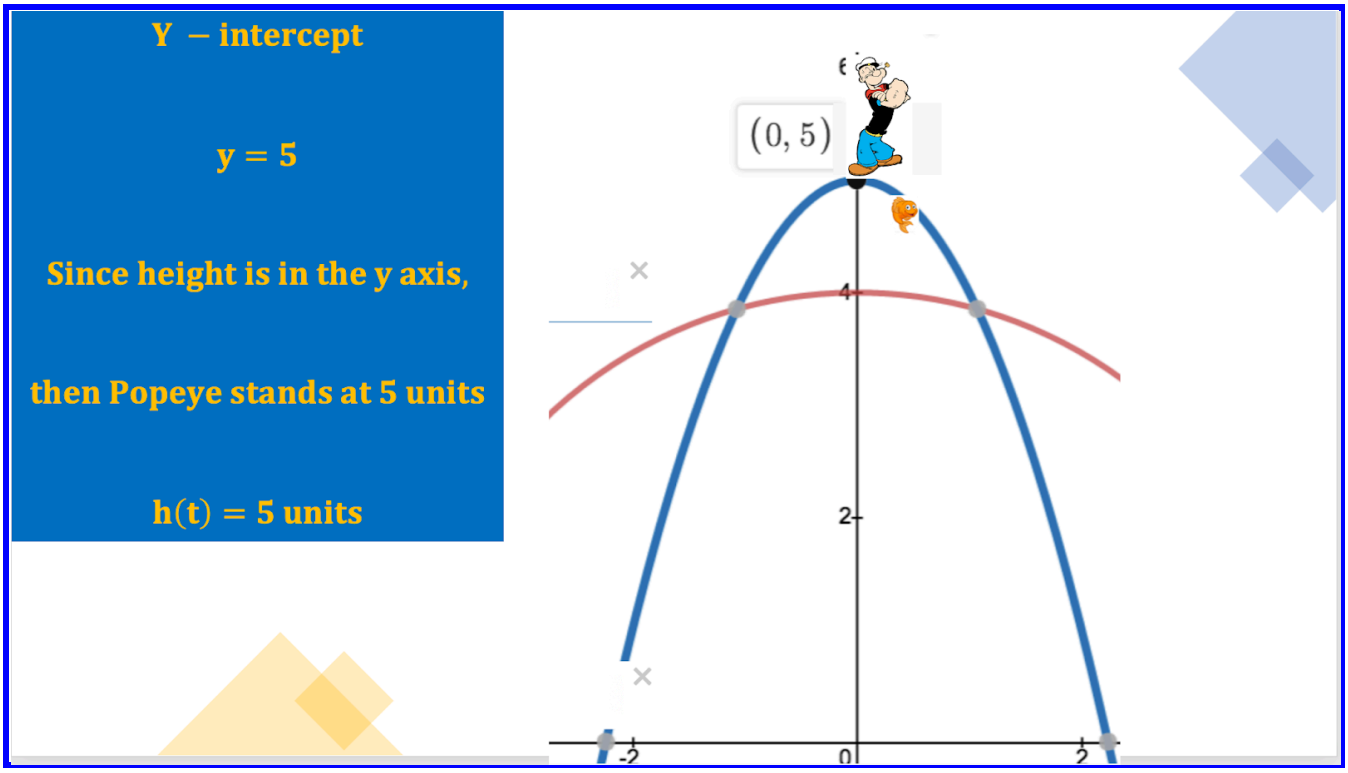

Figure 9. [18] Calculating the height's Popeye standing while he plays with the dolphin and fish.

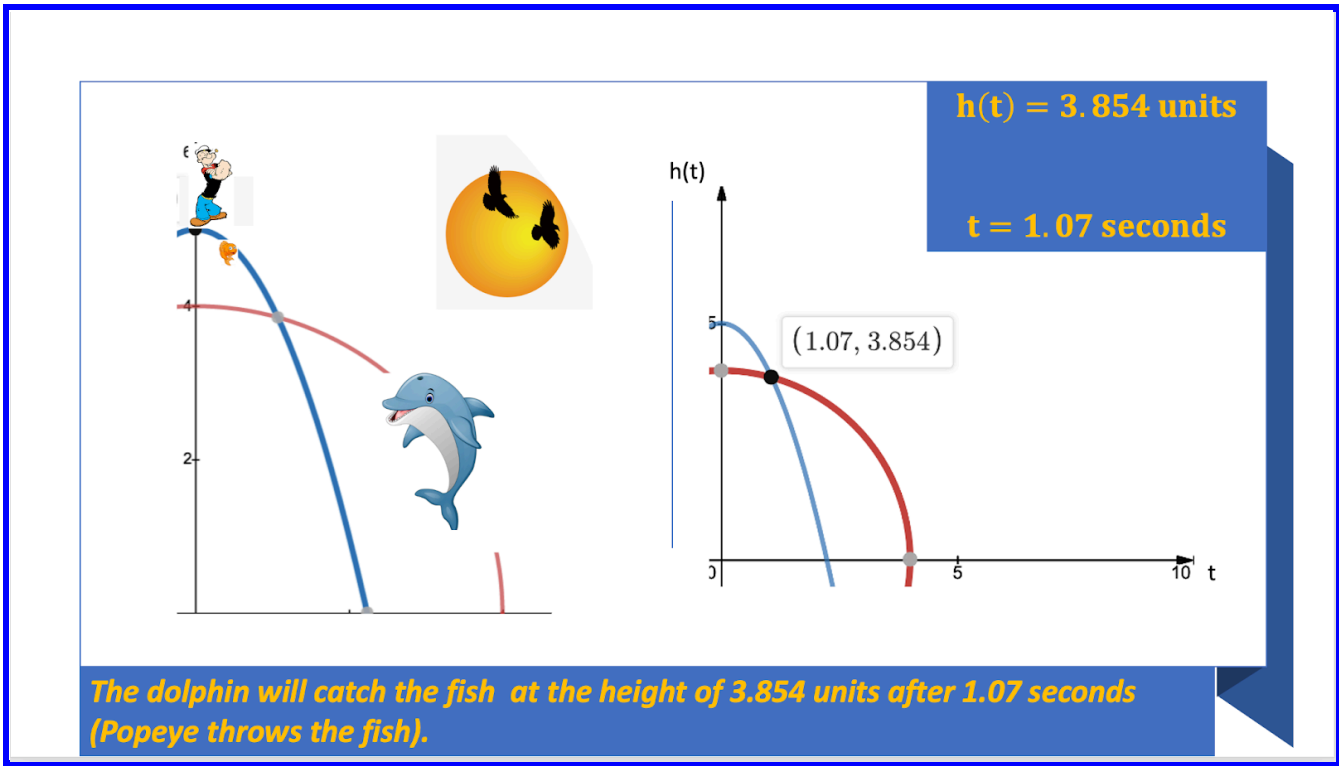

Figure 10. [4] [18] Calculating the point when the dolphin catches the fish. The question is asking at what time the dolphin will catch the fish and at what height above the sea level.

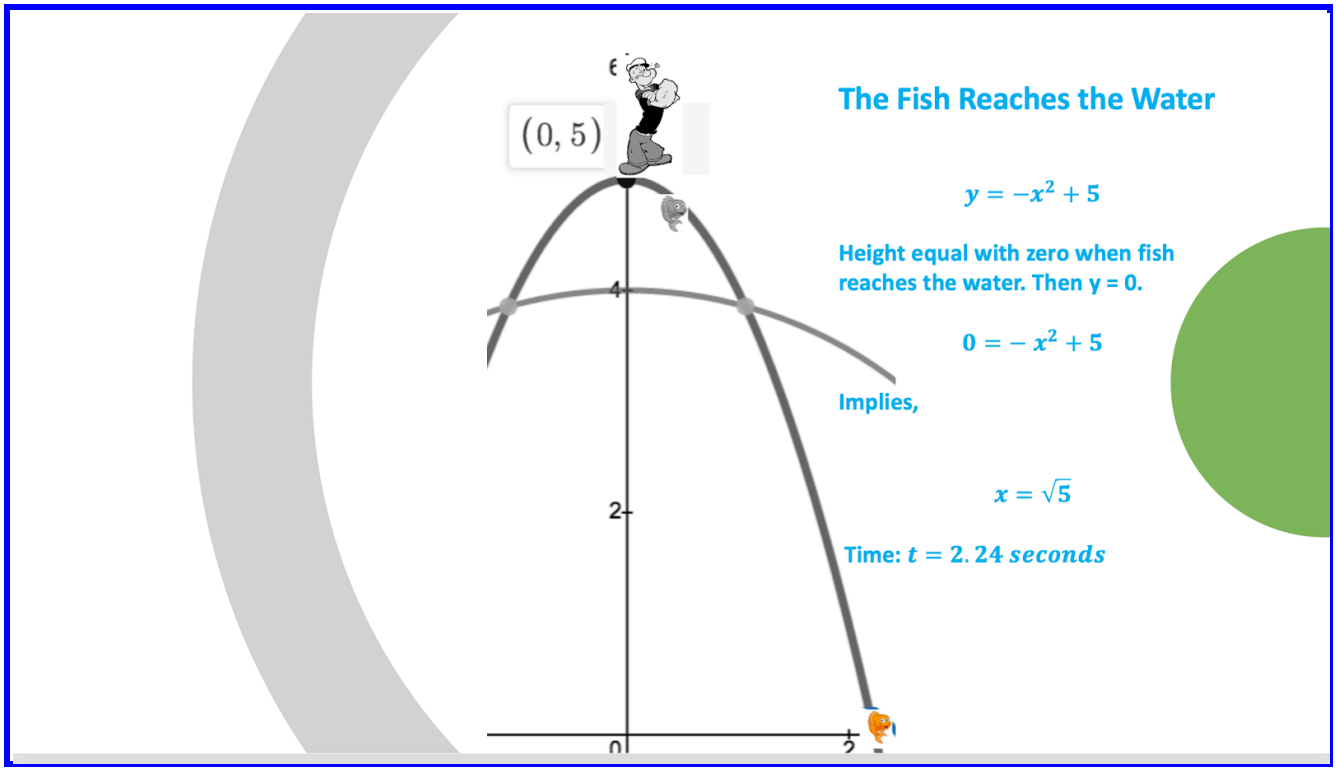

Figure 11. [4] If the dolphin misses the fish then the fish will end up in the water. The question is how long will it take the fish to reach the water? Calculation of the time is presented in the figure.

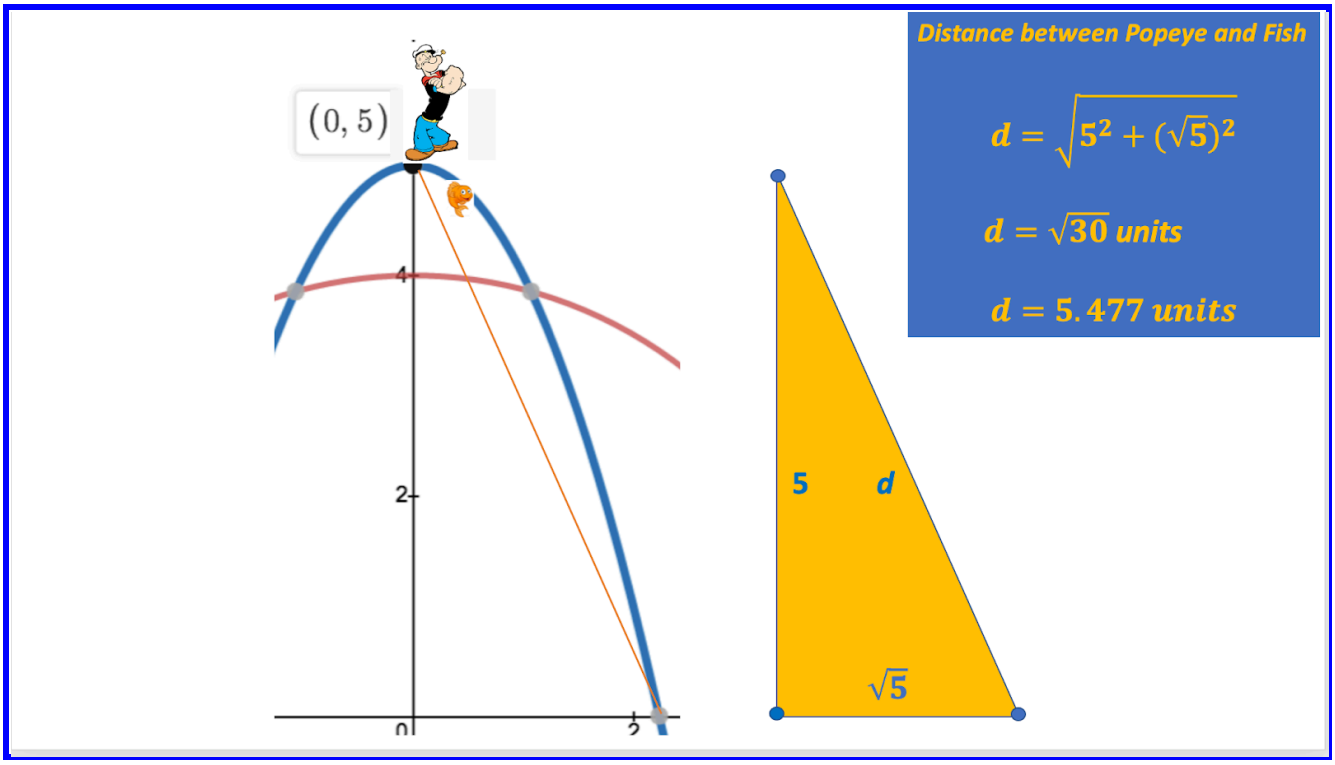

Figure 12. [4] When the fish reaches the water, the question asks, what is the distance between the Popeye and the fish?

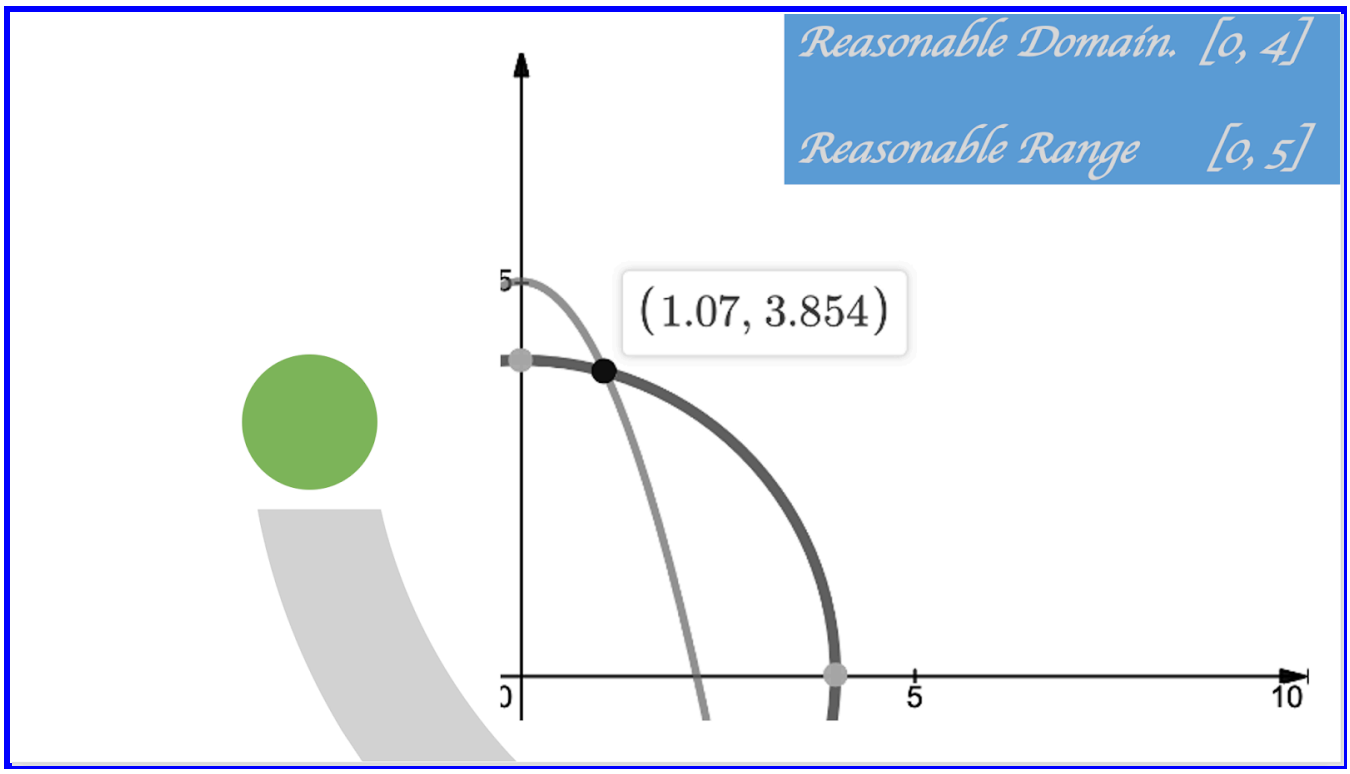

Figure 13. Reasonable domain in the real-world scenario, usually is in the first quadrant; therefore, the reasonable domain in the real cartoon scenario is in the first quadrant.

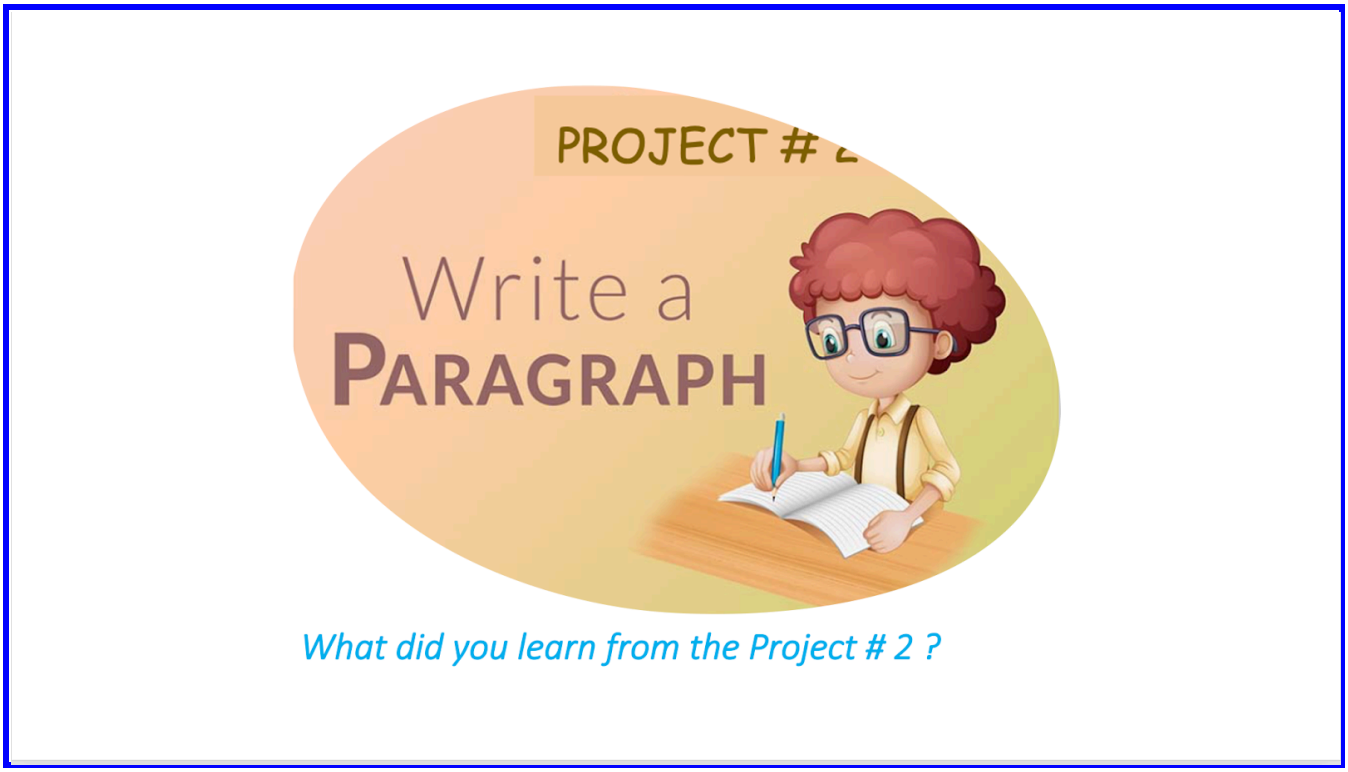

Figure 14. [21] Students will describe the learning outcome from the project. Some examples are illustrated in **Figure 16.**

3 Discussion

The project, *Explore a Cartoon Example,* has a close relationship with a real world example that is given as a word problem. The example involves solving analytically and graphically: quadratic equations, conic sections (circle), finding zeros of the polynomial equation of higher degree. In the addition, the project involves critical thinking to analyze and compare the points of intersections of the circle and the parabola with the zeros of the quartic polynomial equation. Comparing and contrasting is not an easy task regardless of the subject. For instance, reading a passage for students causes critical thinking. The article, *Instructional Approaches to Improving Students' Writing of Compare-Contrast Essays: An Experimental Study, claims,* "Compare-contrast discourse form, students should not simply recall and list information they have acquired from reading about two topics; instead, they should actively work with knowledge of both simultaneously" [10]. The same way happens when students analyze mathematical examples. For instance, comparing the points of intersections of the circle and the parabola with zeros of quartic equation demands to analyze three different activities (elements of the circle, elements of the parabola, and elements of polynomial equations/functions of higher degree). The real-world examples compel students to apply critical thinking as a tool to analyze components that contribute to solving the problem.

They have to use the previous knowledge in algebra and find relationships that happen in two or three different mathematical concepts. The project contains multiple steps such as: finding the distance between two points, Identifying the reasonable domain and the range in the real world. Finding the time when the fish reaches the water, Calculating the height when the dolphin catches the fish, etc. The whole process of the project goes through several steps, as a result, students need to apply multiple mathematical strategies until they complete the work. When students complete the project, they gain a good experience how to solve real world examples. In addition, students will expand the previous skills on modeling examples in the real world. Exploring elements of various scenarios in the real world such as determining measurements of natural objects, calculating velocity of an object, evaluating the frame- work of an activity; it is apparent that it participates in the different scientific fields (Kinematics, Statics, Physics, etc.) The assigned project in any subject must satisfy the educational curriculum. According to the article, *Outcome of Project - Based and Inquiry - Based Learning Activities*, "Also, instructional strategies in school science should meet the goals of science education. [17]" Regardless in which field is given a real example, we need to observe, analyze, and find out parameters by using the language of mathematics. The project # 2 deals with verifying several facts that hypothetically might happen in the real world. The bottom line is to calculate physical measurements mathematically.

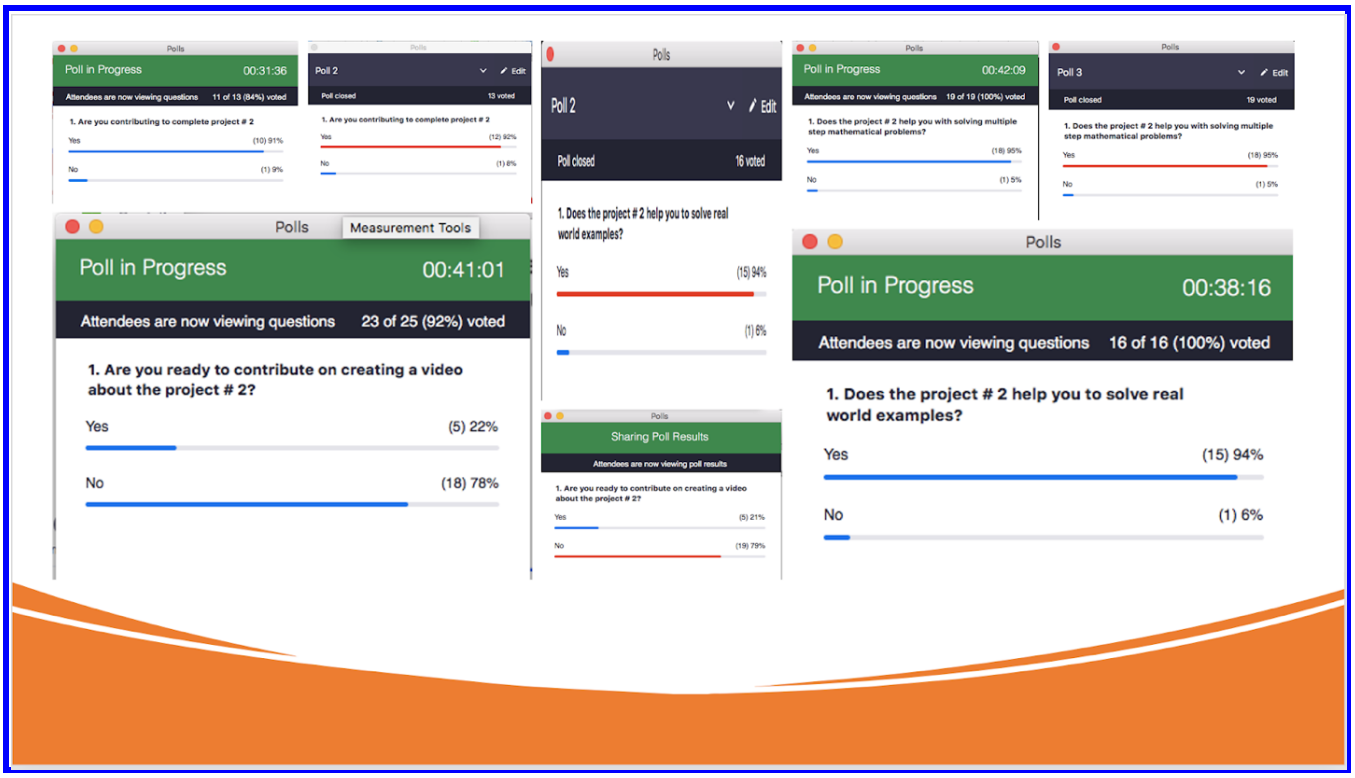

Figure 15. The poll in the ZOOM that asks students about the significance of the projects on helping them with real world examples and solving multi step mathematical problems.

All students should contribute to completing the project. The article, *PBL 2.0: enhances problem - based learning through increased student participation*, claims, "In order for this interaction to occur, all students must be prepared to discuss the learning objectives for the case" [7]. Even though the project is mandatory for all students to participate, some students are less active. Nonetheless, some students are more comfortable with interpersonal intelligence, and others with intrapersonal intelligence. Students with interpersonal intelligence preferences will contribute more with the collective study. Students with intrapersonal intelligence preferences might not contribute sufficiently, but they will get the chance to learn a great percentage of the content by interacting with other students. Sharing ideas contributes with the general growth of learning outcomes for all students.

The good project usually inspires students engaging and contributing to the group work; students were very active with the creative work presented in the PowerPoint presentation. Few of the projects were less creative, but still they satisfied the projects' criteria. Based on the article, *What Makes a Good Project - Eight Elements to Guide Great Project Design,* states, "*Making* things better than being passive, but making things is better still" [19]! Most of the projects that students completed were great (25 out of 30 projects); all the projects contained the correct content, nevertheless, students showed a great performance on expressing ideas (answers) with motion pictures in the power points. It was very hard to decide which one was the best because there are many projects that satisfy all the conditions to classify as the best.

Explore a real carton Example incorporates visual classy figures, which relaxes partakers of the project while they are searching answers or solutions to any given question. Cartoon pictures with Popeye and dolphin are adorable pictures, it motivated students intrinsically to work actively in completing the project #2. In addition, pictures motivated students with visual intelligence and boosted super learning.

4 Results

The learning objective by the end of completing the project students will enhance their skills on following areas:

- Students will improve their skills on exploring real world examples.
- Students will share their mathematical ideas with others.
- Students will think critically on solving real world problems.

- Students will improve their skills on creativity.
- Students will gain confidence in dealing with solving math problems.
- Students will retain more information about mathematical lessons related to the project.

Project based learning (project # 2) reflects a multidimensional purpose in providing students with an overall improvement in mathematics. In addition, project-based learning might find a broad application in other fields, too. For instance, project-based learning in engineering motivates students to learn effectively. According to the article, *Learning Outcome of a Junior-Level Project Based Learning (PBL) Course: Preparation for Capstone,* says, "Project based learning (PBL) is a well-recognized pedagogical approach that is known to strongly motivate students and enhance student learning" [17]. Similarly, the project # 2 objective sheds light on a student's learning outcome. They see mathematics from a different perspective that completes the meaning of the lessons that students elaborated in Algebra 2.
Students have improved their skills on exploring real world examples because the project # 2 asks to apply solving strategies mathematical strategies in multistep. They gained experience with methodologies in analyzing examples from the perspective of physics, as a result, students enhanced their researching strategies. Based on the article, *Motivating Students for Project-Based- Learning for Application of Research Methodology Skills*, claims, "PBL has helped students to apply research methodology skills" [15]. Playing a part in the project, gave the chance to each student to use several methods on solving the problem and identifying required measurements. The application of the given mathematical methods in the project # 2, assists them with a better understanding of real-world examples.
While students were working in their groups, they shared ideas about the solution, displaying the pictures on the PowerPoint, and describing the solutions with the given pictures. Each group was interested in getting a better grade, therefore, they collaborated on seeking for better results. The article, The Impact of Employing the (Think - Pair - Share) Strategy to Gain Some Number Sense Skills and Mathematical Communication, states, "...cooperative and group work between students, helping to make the student an effective and active element in the classroom, which is the essence of the development of mathematical communication and number sense skills [1]." Communication was a powerful tool to each group on enhancing in general the work and completing the project # 2. The good projects manifested a good communication between students during the completion of the project; on the other hand, great projects reflected a great and massive collaboration among students within their groups.

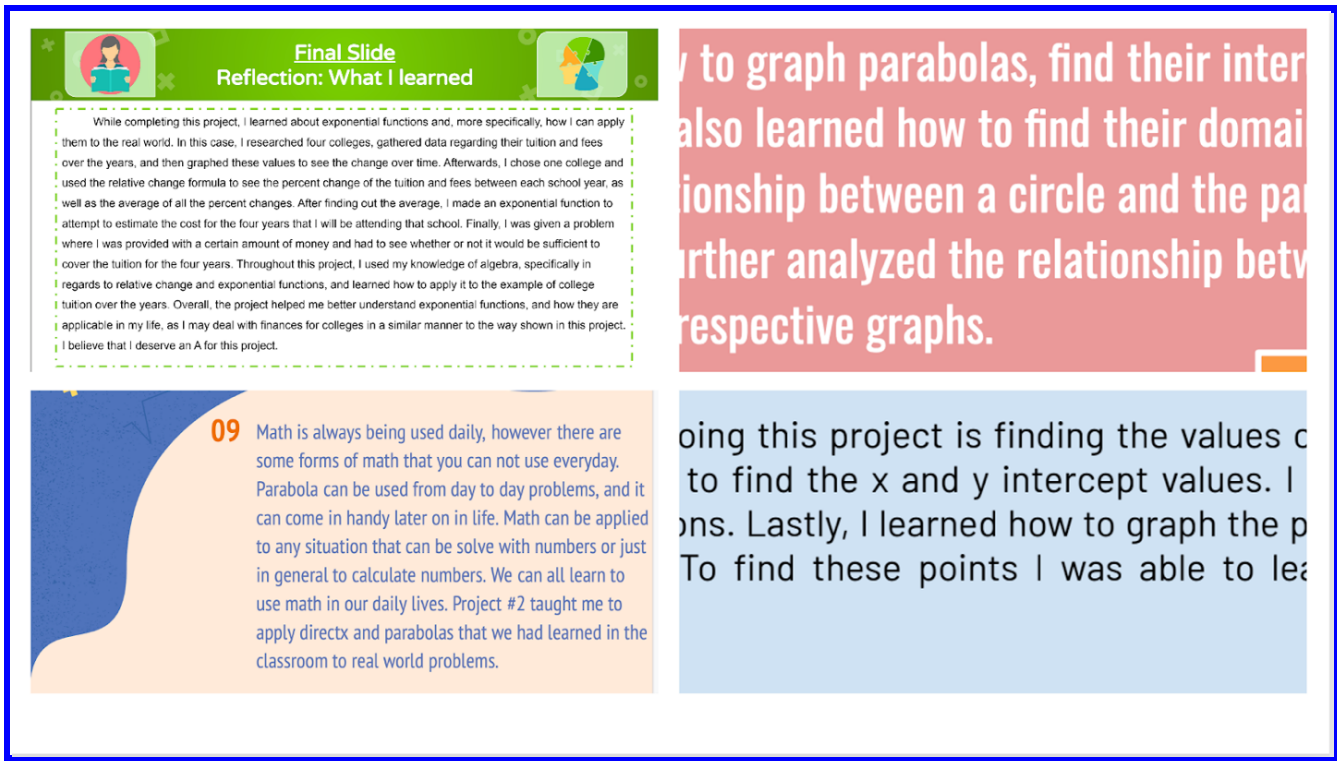

Figure 16. The last slide of the PowerPoint in a few different projects where students reflect on what they have learnt after they completed the project.

The real-world problems are usually complex and require a deeper analysis in order to find the solution. Also, the project #2 involves questions, which needs applying higher order thinking skills. The article, *Real Problem Solving and Real Learning,* says," Students no longer look for a quick or short-term answer. The goal of learning shifts to gaining critical information to solve or resolve an important problem or concern" [14]. Referring to the PowerPoint Fig. 4 and Fig 5., students applied several solving strategies until they have gotten the right answer. In the addition, students used deep thinking when they compared and contrasted the point of intersections between the circle - parabola, and quartic polynomial equations. Critical thinking is involved throughout the process of completing the work such as, finding the time when the fish reaches the surface area of the water, Finding the distance between the Popeye and the fish, and determining the reasonable domain and the range of the circle and parabola in the real-world example.

The timeframe to return the project #2 was 4 weeks. In the first two weeks, I did not give clues; by the end of the frame-time, I gave students more clues on how to complete the work. According to the article, Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students, states, "During the lesson, allow students to consult solved problems independently or in groups to understand different ways to solve a problem when they are unsure how to proceed" [8]. In certain situations, students struggled to find a solution only by elimination method, so they combined substitutions and elimination methods. In other cases, they found some shortcuts on analytical work. In the perspective of visual work students were enormously creative by using technology extraordinarily well.

Elaborating mathematical strategies that students learned before, they exercised in different contexts by using them into the project. Students learned when they had to use nonlinear systems with elimination methods, when to use nonlinear systems with substitution methods, when to use Pythagorean theorem, when to use quadratic formulas…Based on the article, 4 *Small Ways to Build Student Confidence,* claims, "Students shouldn't just memorize and regurgitate formulas. Three out of four teachers agree that students need to not only understand math concepts, but also know when and how to apply them - the good news is that students can have success in math class with the right effort, attitude, and behavior, regardless of a natural affinity or being 'good at math." [12]. Most groups completed great projects and showed all necessary steps from the first PowerPoint slides to the last one. The frame time to complete the work and quantity/quality of the questions compelled students to apply mathematical strategies wisely.

The wise Latin expression says, "Repetition makes perfect." The procedure of the project # 2 relates with the previous lessons that were delivered in the class. Listing from the first slide to the last one demands to use previous mathematical techniques that are familiar to students. Based on the article, *Ebbinghaus' Forgetting Curve Explained: The Importance of Spaced Learning for Memory, "*If you use spaced learning, that Ebbinghaus forgetting curve will turn into a shallow-sloping retention curve, meaning you can enjoy access to more of that knowledge for much longer" [20]. Students worked in the project # 2 for four weeks - analyzing information of the project, sharing information within the group, choosing the best answers of the group, completing all slides in the order. The process takes time; students apply the space time and repetition. As a result, the information and math strategies in the project will remain longer to every student.

5 Conclusion

Problem based learning enhances students' skill to research in various fields that is a part of modern education. Development of education grows with respect to the economy and vice versa. The economy of the twenty-first century demands students' skills oriented in research study. According to the article *Why is the Project - Based Learning Important, states* "Solving highly complex problems requires that students have both fundamental skills (reading, writing, and math) and 21st century skills (teamwork, problem solving, research gathering, time management, information synthesizing, utilizing high tech tools)" [6]. Students develop a study culture which provides them with a study habit reflected on seeking data, analyzing data, sharing ideas with students, aligning their ideas with intention to find a positive outcome. *The project, Explore a Cartoon Example,* is similar with the real world example. In the beginning there is the word problem given entirely with words, and then students should translate the verbal text into mathematical statements. Students should read and examine the word problem carefully. They should identify the key words and match them with the mathematical strategies that they learned in algebra. Students already have explored the modeling of mathematical strategies they learned in the s similarly with the real-world problems. The article, *Getting a Grip on Project-Based-Learning: Theory, Case, and Recommendation*, says, "So, through conducting investigations, conversations or activities, an individual is learning by constructing new knowledge by building on their current knowledge" [11]. The project # 2 has many new elements and the solution demands multiple steps processes, but most of the components are related with the previous lessons. Apparently, students will build the new knowledge over the foundation of

the old knowledge. Practical approach in the new knowledge explores activities of the research work. The whole process is a small picture of a serious research work in a particular field.

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