Culturally Responsive Teaching: Connecting Mathematics to Art

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Abstract: *The author presents an activity designed to help preservice mathematics teachers begin to understand how they can make their lessons more culturally responsive by connecting content to everyday contexts while incorporating students' interests and culture in their teaching.*

Keywords: *culturally responsive teaching, art, connections, preservice teachers*

1 Introduction

An important component of quality mathematics instruction is providing learners with purposeful learning experiences. This involves learners experiencing real-world, relevant, or meaningful mathematics (Sparrow, 2008b). Real-world connections, meanings, and experiences can provide contexts for understanding mathematical concepts. Connecting mathematics to everyday contexts is emphasized in the *Model with Mathematics* standard for mathematical practice (CCSSO, 2010). This means that learners need to use mathematics to model the world around them. The National Council of Teachers of Mathematics (NCTM) standards also call for all instructional programs to enable students to recognize and apply mathematics in contexts outside of mathematics (NCTM, 2000).

On the other hand, an important characteristic of effective teachers is to be culturally responsive, helping students to see mathematics in their lives and in their cultural backgrounds. Gay (2010) defines culturally responsive pedagogy as teaching "to and through students' personal and cultural strengths, their intellectual capabilities, and their prior accomplishments" (p. 26). A culturally responsive teacher uses examples, illustrations, and content from a variety of cultures to illustrate key concepts in the content area. The need to prepare culturally responsive teachers is emphasized by professional bodies and accreditation boards. For instance, The Council for the Accreditation of Educator Preparation (CAEP) recognizes that culturally responsive teachers play a crucial role in ensuring academic success of students from diverse backgrounds (CAEP, 2020). The CAEP standards call for high academic achievement combined with strong clinical experiences to ensure that teachers are well-prepared to encourage all students to perform at high levels of mathematical proficiency. The need to prepare culturally responsive teachers is emphasized by edTPA (SCALE, 2020), a summative assessment that teacher candidates complete during student teaching. The assessment requires preservice teachers to explain and demonstrate how they incorporate students' personal, cultural and community assets in their lessons.

Culturally responsive teachers are more self-conscious, critical, and analytical of their own teaching beliefs and behaviors (Gay & Kirkland, 2003). Preservice teachers need to engage in self-reflection, exploration, and critical self-analysis to develop sociocultural awareness (Gay & Kirkland, 2003; Villegas & Lucas, 2002). Teachers need to know who they are, they need to understand the contexts in which they teach, and they need to question their knowledge and assumptions (Gay & Kirkland, 2003). These qualities are as important to good teaching as the mastery of techniques for instructional effectiveness.

While much has been written about culturally responsive teaching, too few know how to teach subject specific content from this perspective (Ukpokodu, 2011). For preservice teachers specifically, many of the ideas about culturally responsive teaching are abstract since few have had practical experience with this style of instruction. Prior to engaging teacher candidates in culturally responsive teaching, I surveyed my students about their understanding of the topic. Few indicated that they knew what culturally responsive teaching was. The majority were not sure how to incorporate culturally responsive strategies in their teaching of mathematics. A preliminary analysis of edTPA data generated by student teachers at our university indicated that many were unable to articulate what personal and cultural assets they could draw upon from the communities in which they taught (Wachira, manuscript in progress). Ukpokodu (2011) found that mathematics teachers tend to avoid culturally responsive instruction because they lack models to emulate. In the following article, I aim to provide such a model—providing preservice teachers with a specific example that connects mathematics and art in a way that encourages students to explore their own culture.

2 Lesson and activity

One way to be culturally responsive is to teach from a constructivist perspective (Wachira & Mburu, 2017). Because learning from a constructivist perspective is necessarily experiential, making connections to students' lives, culture, and interests is an essential part of constructivist teaching. This paper presents a hands-on art activity, adopted from Lewis (2007), that engages preservice middle school teachers in explorations of mathematics and art through the study of the Pythagoras theorem and irrational numbers. Because art can provide a way to connect students' everyday lives, culture, and personal interests, this paper extends the work by Lewis by asking preservice teachers to reflect on how art can be used to examine their own identity and reflect on their culture. While irrational numbers is not covered in-depth in middle school, the activity provides a fun way to introduce the topic.

The lesson begins with a viewing of the Disney classic video *Donald in Mathmagic Land* (2009) that introduces Pythagoras and gives a brief history of the Pythagorean society. The video shows where mathematics can be found in everyday life. In the video, many ideas are demonstrated visually, making it easy for students to see the relevance of mathematics in everyday life. After watching the movie, we discuss the real number system. Specifically, candidates note that irrational numbers are a subset of real numbers and thus can be associated with a unique point on the number line (Wachira, 2009). The art activity, the Wheel of Theodorus, is then introduced as a means for extending understanding of irrational numbers.

3 Creating the wheel of Theodorus

3.1 Step 1

Construct a right triangle with the legs measuring one inch and determine the length of the hypotenuse. By the Pythagoras theorem, $a^2 + b^2 = c^2$ where a and b are the lengths of the two

legs of a triangle and c is the hypotenuse. Using this formula, we can compute the measure of the hypotenuse for a triangle when legs each have measure of one inch.

$$\begin{aligned} c^2 &= 1^2 + 1^2 \Rightarrow \\ c^2 &= 2 \Rightarrow \\ c &= \sqrt{2} \end{aligned}$$

This relationship is illustrated in Figure 1.

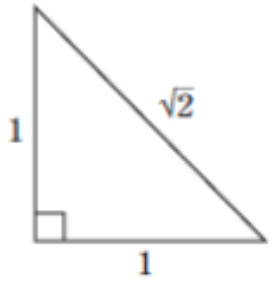

Fig. 1: *Right triangle with legs measuring 1 inch.*

3.2 Step 2

The hypotenuse of the triangle in Step 1 measuring

$$\sqrt{2}$$

inches, then becomes the length of the base for the next triangle. We construct another right triangle with the adjacent leg measuring 1 inch. For the second triangle the hypotenuse is calculated as shown in Figure 2.

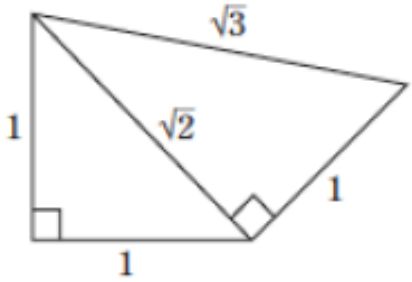

Fig. 2: *Constructing a second right triangle from the hypotenuse of the first.*

$$\begin{aligned} 1^2 + \left(\sqrt{2}\right)^2 &= c^2 \Rightarrow \\ 3 &= c^2 \Rightarrow \\ \sqrt{3} &= c \end{aligned}$$

From this step the preservice teachers were able to see that $(\sqrt{n})^2 = n$.

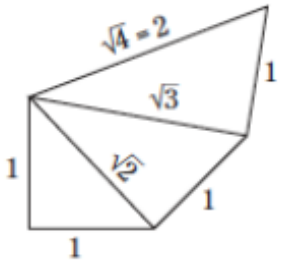

Fig. 3: *Constructing a third right triangle from the hypotenuse of the second.*

3.3 Step 3

We continue this process repeatedly. As Figure 3 suggests, the hypotenuse of the most recent triangle becomes the long leg of a new right triangle. The length of the other leg is held constant at 1 inch. The length of the hypotenuse for the third triangle is calculated as follows.

$$\begin{aligned} 1^2 + \left(\sqrt{3}\right)^2 &= c^2 \Rightarrow \\ 1 + 3 &= c^2 \Rightarrow \\ \sqrt{4} &= c \Rightarrow \\ 2 &= c \end{aligned}$$

This process is repeated several more times. At each stage, I remind the teacher candidates to label the lengths of each side and include calculations for the hypotenuse. As candidates continue their constructions, a spiral, the Wheel of Theodorus, is created. I ask candidates to make at least 18 triangles to ensure that the spiral is apparent in their work. An example spiral, formed by outer segments of length 1, is illustrated in Figure 4.

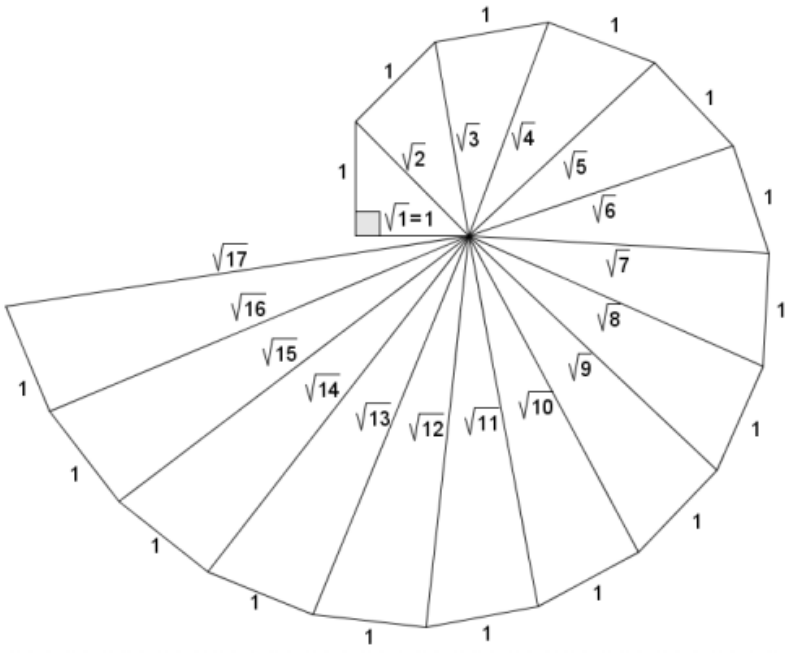

Fig. 4: *Wheel of Theodorus.*

4 Connecting Mathematics and Art

After introducing the Wheel of Theodorus to candidates, I ask them to create their own spiral on poster paper as homework. This requires them to scale the measures of the triangles—an excellent context for exploring ratios and proportions. In addition, I ask the candidates to transform their spiral into a piece of artwork reflecting something from their everyday life, culture, or community of interest to them. Drawing ideas from the Disney video and their own everyday contexts, the preservice teachers decorate their wheels. I encourage them to make use of color and imagery, creating works with as much detail as possible. The candidates title, sign, and date their work, similar to what artists do. After the projects are completed, each preservice teacher gives a short presentation highlighting what their composition represents to them and what motivated the subject of their creation. I display all of their artwork in our classroom gallery. Peers provide feedback on their colleagues' work. In addition, I provide candidates with a rubric to assess their peers' work in terms of creativity, connections to real life, theme, and mathematics (e.g., *Are calculations correct? Do all triangles include a right angle? Are the sides labeled correctly with the hypotenuse in radical form?*).

5 Sharing the Art Projects

Examples of several projects are provided in Figures 5-9. As you examine the work samples, consider ways in which the pieces depict the interests and cultures of preservice teachers. The projects demonstrate many different aspects of their lives, including popular culture, TV, music and movies, fictional books, sports, animals and themes from nature.

Fig. 5: *The Yellow Brick Road.*

A notable project, *The Yellow Brick Road* (Figure 5), was based on the children's book and movie *The Wizard of Oz*. Another project, *The Theodoran Sorcerer* (Figure 6), draws from the popular book series, *Harry Potter*. Other projects drew from popular teen games and shows such as Pokémon and Minecraft.

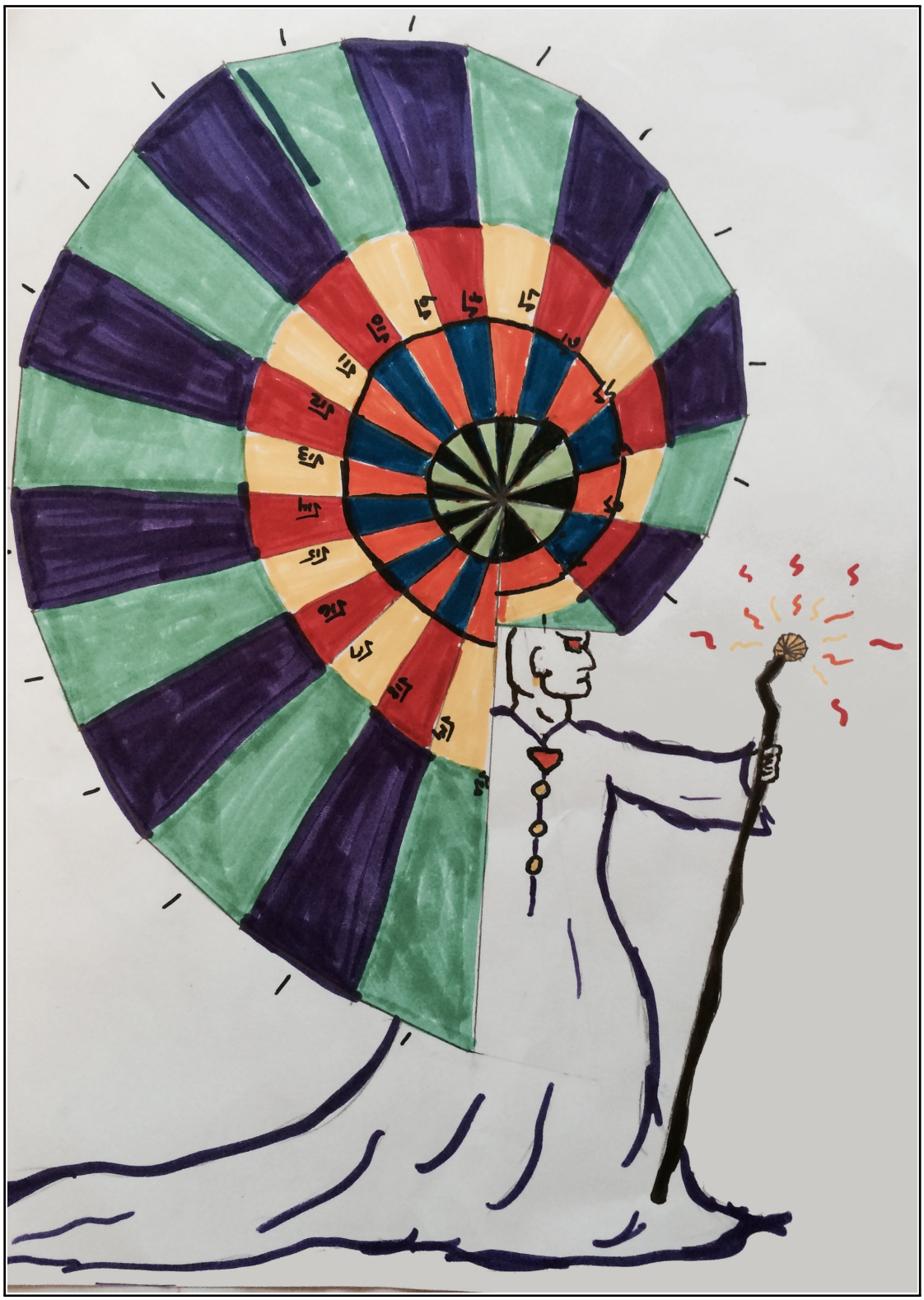

Fig. 6: *The Theodoran Sorcerer.*

Sports was another popular aspect of the preservice teachers lives that was captured in their projects. Projects that incorporated sports mostly depicted a favorite professional team. Several incorporated football (Figure 7) and baseball (Figure 8).

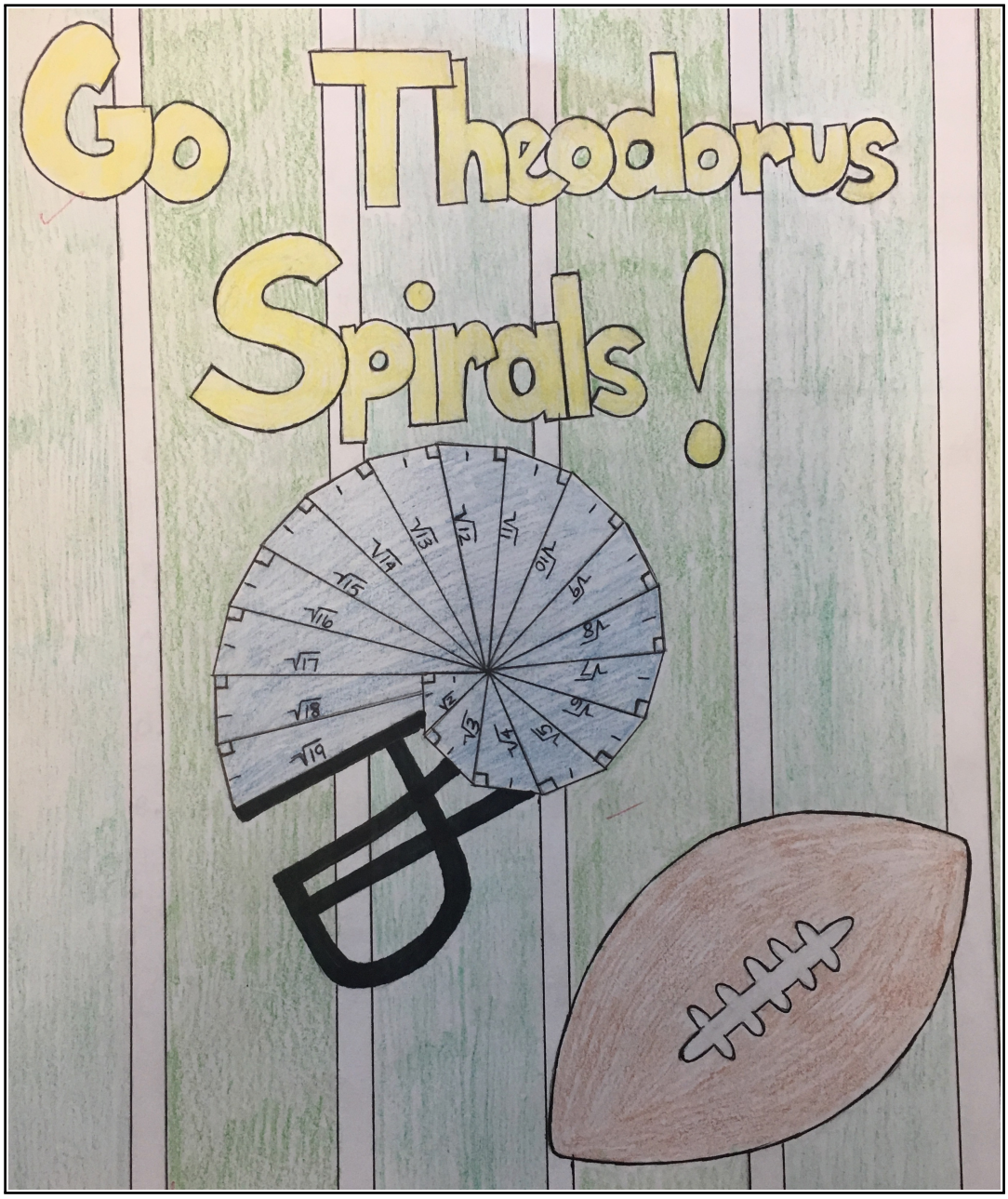

Fig. 7: *Theodorus Spirals Football.*

Several other projects incorporated the holidays. The teachers said that they loved the holidays showing how these cultural traditions were important to the lives of these teachers. There were art projects about Thanksgiving, Halloween and Christmas. One preservice teacher reflected on the Christmas holiday while incorporating Gary the Snail, a character from the popular TV show *Spongebob Squarepants*, into her work (Figure 9). Preservice teachers were also interested in nature and animals. Several other projects depicted weather, animals, and birds.

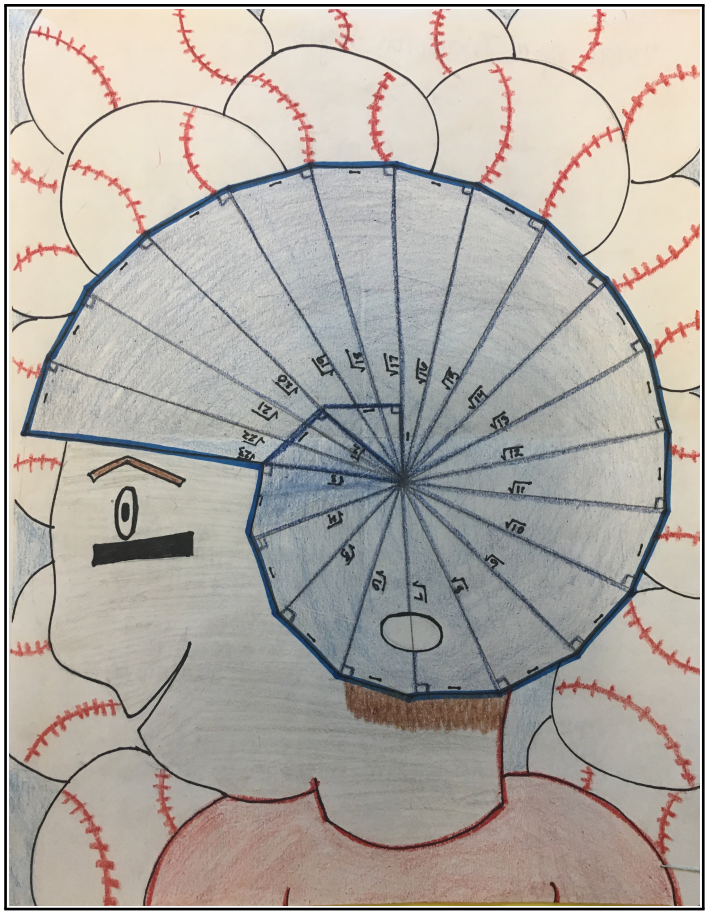

Fig. 8: *Baseball Theodorus.*

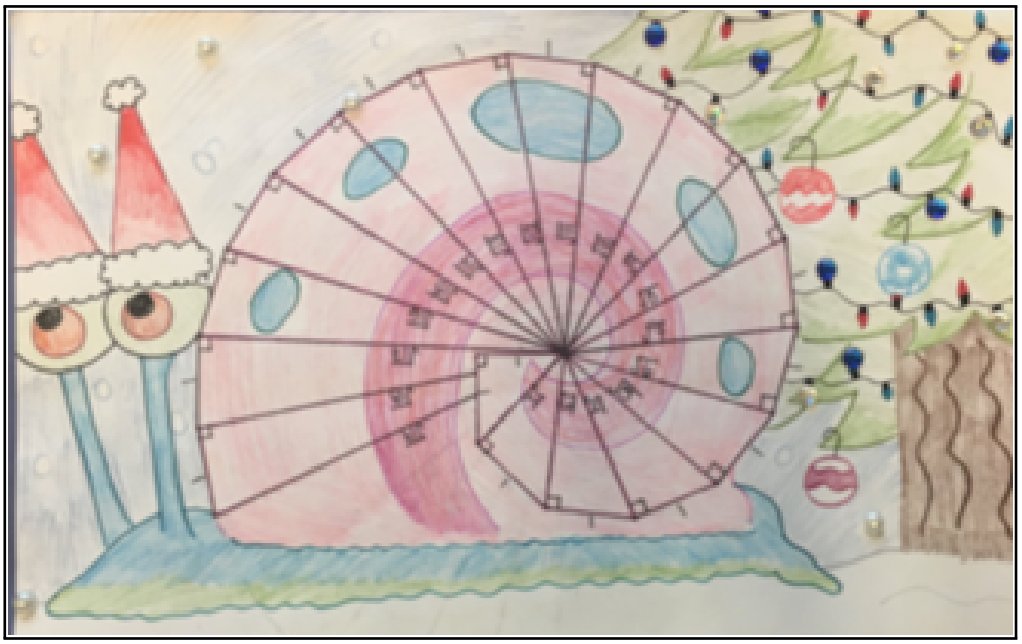

Fig. 9: *A Christmas Gary.*

6 Key mathematics concepts learned

Through art, this project helped preservice teachers reflect on their own culture while at the same time learning how to help future students connect mathematics to everyday contexts. After completing the project, I ask teacher candidates to consider key mathematical concepts that they learned from the activity. Candidates typically note that the lesson helps reinforce and practice using the Pythagoras theorem. In particular, the activity helps students understand that the Pythagoras theorem is used to compute the unknown side of a triangle when the other two sides are known. Since students are required to label the right angle and the sides of the triangles, the lesson emphasizes that the theorem applies only to right triangles. The activity also helps students see that radical numbers may be rational (since $\sqrt{4} = 2$, $\sqrt{9} = 3$, and $\sqrt{16} = 4$) and that the square of a square root is the number itself, that is, $(\sqrt{n})^2$. Similarly, they learned that $\sqrt{n^2} = n$, a fact that makes simplifying radicals much easier. The activity also helped preservice teachers develop a stronger sense of irrational numbers. For instance, from their work with triangles, candidates recognized that the magnitude of $\sqrt{3}$ as a number a slightly less than 2.

7 Discussion and Conclusion

This art project described in this paper is just one example of how educators can incorporate culturally responsive practices into their teaching. When teachers incorporate aspects of students' personal interests and culture in their teaching they demonstrate responsiveness to their students. From this activity, the preservice teachers learn that culturally responsive teaching is student-centered and by encouraging students to draw from their personal interests and everyday context in making their own artistic choices then we are placing them at the center of learning.

This activity shows how teachers can create opportunities to make connections with other disciplines such as art, social studies or science, thus helping preservice teachers meet an important Association for Middle Level Education (AMLE, 2020) standard which calls for middle level teacher candidates to be able to demonstrate the interdisciplinary nature of knowledge by helping all young adolescents make connections among subject areas. AMLE calls for teachers to facilitate relationships among content, ideas, interests, and experiences by developing and implementing relevant, challenging, integrative, and exploratory curriculum.

The art project described in this paper is just one of the many ideas about culturally responsive teaching practices. What is important is that such practices build on students' personal and cultural strengths (Gay, 2010) as the knowledge students bring to school is central to knowledge construction. As noted by Williams et al., (2016) teachers who are culturally responsive engage in critical reflection about race and culture, which informs their mathematics teaching and supports the sustainable development of practices that are culturally responsive. Other culturally responsive practices include,

- Linking mathematics language to everyday activities like cooking and shopping and engaging with families (Orosco & Abdulrahim, 2017);
- Incorporating stories into instruction featuring characters from their race and background who solved everyday mathematical problems (Corp, 2017);
- Integrating music, movement, rhythm, dance, oral story-telling, and choral responses (Cholewa et al. 2012) especially from communities that have strong story-telling and oral traditions;
- Use of native language during instruction to facilitate learning (Matthews & López 2018);

- Teaching for social justice in which teachers raise student awareness of social injustices and forces that perpetuate them (Ladson-Billings, 1995a). Students can use mathematics as tools to analyze such issues as inequity, social oppression and poverty (Gregson, 2013).

These practices increase students' interest and motivation and in turn increase mathematical understanding. In conclusion, students are more likely to develop positive attitude towards mathematics when teachers provide them with ways to make it enjoyable and relevant by connecting to their culture and to the mathematics they find outside of their school.

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