Exploring the Rhind Papyrus

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In this article, we introduce the ancient Rhind papyrus. The Rhind papyrus serves as the foundation of mathematics today as it includes various mathematical techniques such as proportions, algebra, volume, and geometry. While many mathematical strategies are written on the Rhind papyrus, this article explores the ancient Egyptians approach to finding the area of a circle. Mirroring the Egyptians' approach to comparing shapes to find information, this article explores a middle school activity that can be used in a similar way.

Introduction

Mathematics, along with music, is considered a standard language that is understood by almost every culture throughout the world. In fact, it is believed that every human culture, past or present, has used mathematics to some degree. The contributions made by multiple nations over the past couple of centuries have resulted in the standard of mathematics that is used today (Cooke, 1997). Mathematics of ancient civilizations, such as Egypt and Greece, are considered particularly advanced as they reached a high degree of development. The Rhind papyrus was discovered in the 19th century and dates back to 1650 BCE. This scribe gives modern learners insight into the advanced mathematics of the ancient Egyptians, particularly that of Egyptian geometry. Ideas from the Rhind papyrus can be used today to further classroom discoveries, engagement, and learning.

What is the Rhind Papyrus?

Papyrus is a form of paper that was made of dried papyrus reed and was used daily by ancient Egyptians. On the Egyptian's Rhind papyrus, they recorded a variety of mathematical techniques including notation, proportion, "parts" (the term Egyptians used for fractions), algebra, volume, and geometry. It was discovered by Alexander Henry Rhind in 1865 in Thebes near the ruins of Ramasseum. He found it while visiting Egypt in hope of becoming an Egyptologist. The papyrus was, in fact, named after Alexander Rhind; however, this same historical text is also known as the Ahmose papyrus or the British papyrus (Calinger, 1995).

The papyrus is three and a half feet wide, seventeen feet long and was created from fourteen separate sheets glued end to end. The information in the papyrus is written in a form of hieractic, which is a cursive form of hieroglyphics (Williams and Scott, 2003). Mathematical translation of the papyrus began in the late 19th century; however, it is still incomplete to this day. Although most of the fragile papyri did not survive, the Rhind papyrus was well preserved by the dry Egyptian climate.

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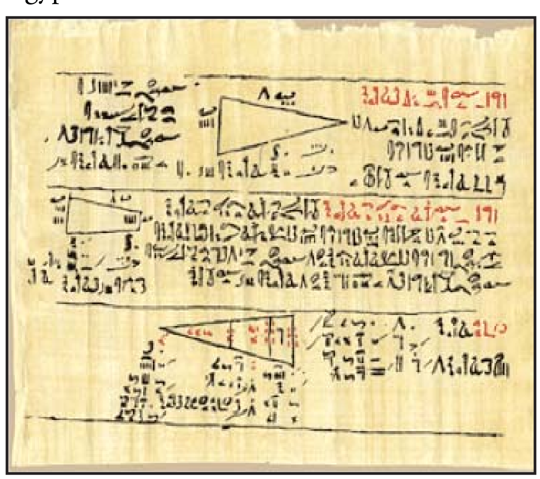

Fig 1 The Rhind Papyrus

Historians have been able to date the Papyrus with such precision because the author of the papyrus, a scribe by the name of Ahmose, states that he was writing in the "fourth month of the flood season of the thirty-third year of the reign of Pharaoh Auserre" (Cooke 1997, p. 27). From this information, historians were able to pinpoint the date to 1650 BCE; however, Ahmose also states that he is only copying information down from the Pharaoh Nymaatre, which would leave the mathematical information contained in the Rhind Papyrus to be almost four thousand years old.

Egyptian Mathematics

The mathematical concepts found on the Rhind Papyrus where purposeful to the Egyptians lifestyle. Because the Egyptians mainly focused on the practical use of mathematics, all of the subject matter found in the Rhind papyrus had a direct connection to their daily needs. For example, the fertile land surrounding the Nile River in Egypt created a large society with a thriving agriculture. Eventually, extensive bartering and trading of farm goods and animals began. The Egyptians developed a number system as well as computation strategies to deal with keeping track of trade. Additionally, the ancient Egyptians had to find a reliable way to tax land, and therefore had to discover a way to measure the area of agricultural fields and other lands (Shutler, 2009). The Rhind papyrus also features a method for finding the volume of a pyramid which was used to construct and build the famous Egyptian pyramids. In addition to the volume of a pyramid, the Egyptians also were interested in finding the volume of barrels that carried liquid goods for trading purposes. From these needs, they developed a set of mathematical concepts.

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Circles

One of the items discussed in the Rhind Papyrus is the Ancient Egyptian method to find the area of the circle. Below is the work explaining their circular computations (shown in hieroglyphics) extracted from the Rhind Papyrus.

More specifically, Figure 2 shows the Egyptians approach to finding the area of a circle with diameter 9 units. Notice within Figure 2 the image to the far right. There appears to be an octagon inside of a square. The interior shape is not a perfect circle because the Egyptians divided the 9 by 9

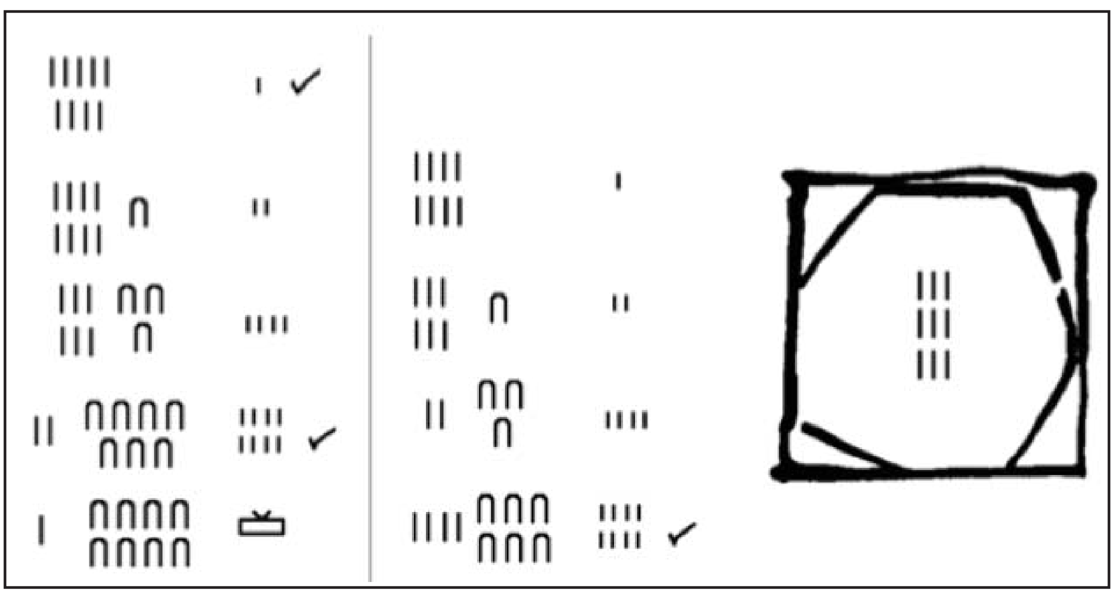

Fig 2 Egyptian area calculations

square into 9 equal sections, and then cut off the four corners leaving an octagon with an area of 63 square units. They switched the area of the octagon to 64 square units since 64 is a perfect square. This would simplify their future computations (Cooke, 1997, p. 28). They assumed the octagon was a close approximation to the circle, and treated it as a circle.

The Egyptians approximated that the area of a circle would be $(D - (1/9)D)^2$ where D stood for diameter (Shutler, 2009). They did not have this exact equation in the papyrus, but this is a representation of their process. Notice that the value π is absent. They did not have any knowledge of the value π and therefore did not use it in the computation of a circle. They assume the area of a circle is the area of a square whose side is formed by removing the ninth part of the diameter, as shown in Figure 3.

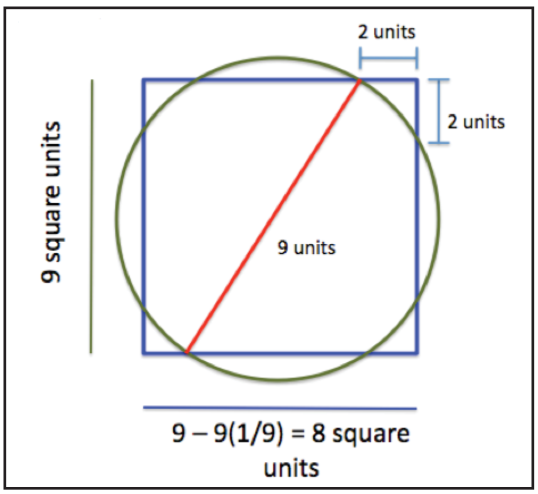

Fig 3 Approximation of the area of a circle

Notice the parts of the circle protruding from the square in Figure 3. These are the parts the Egyptians cut off to make an octagon as shown in Figure 2. They reached this conclusion on the area by starting with a square with side lengths of 8. Next, they drew a circle over the square in which the two shapes intersected 2 units away from each corner of the square, as shown in Figure 3. They estimated that the 4 corners of the square outside the circle are equal to the 4 sections of the circle outside the square. Thus, they assumed the circle and square are equal in area. They said the diameter of the circle is the same as connecting 2 opposite intersections of the circle and square. If measured, this length is about 9 units, or more exactly the square root of 80. Their inspiration for this method originated from pouring the contents of a barrel with a diameter of 9 units into a 8×8 box. The barrel and box had the same height, and the contents appeared to fit exactly (Shutler, 2009). Thus, the bases had the same area, giving reason for them to assume the area of the circle and square in Figure 3 were equal.

In the Classroom

The Egyptian method for finding the area of a circle can be adapted to use in a middle school classroom. Ancient Egyptians relied more on visual observation and estimation in order to find the area of a circle. By doing so, they were still able to find a close approximation of the area. Their approximation, in fact, is nearly equal to the answer achieved by a modern equation using π. Area approximation and estimation can be used in middle school classrooms to help introduce geometric ideas to students who do not fully understand the concept of π. By using a technique similar to that of the ancient Egyptians, students can learn to approximate the area of circular objects until they are able to understand the meaning of π. In doing so, they can discover the importance of π.

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The Egyptians related the area of a circle to that of a square in order to calculate its approximate area. Similarly, Pattern Blocks (shown in Figure 4) could be used in a middle school classroom to explore how the areas of different shapes relate to one another.

Using the blocks, students could explore questions such as the following: 1) "What is the area of the blue rhombus in terms of green triangles?" 2) "How many blue rhombuses fit inside the yellow hexagon?"

3) "Form two congruent shapes, one that is composed of two white rhombuses and one green triangle, and the other that is composed of one orange square and one green triangle." This is illustrated below in Figure 5.

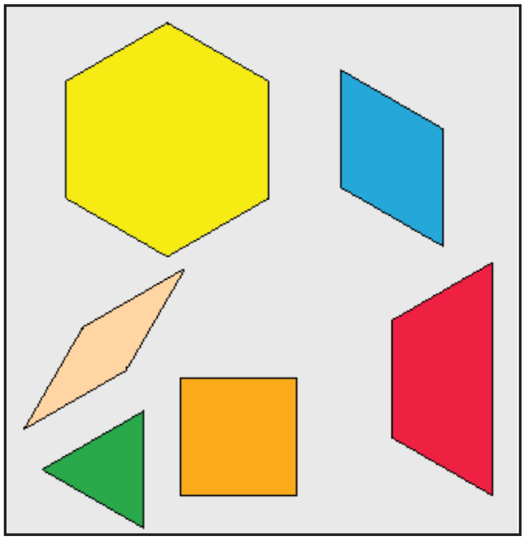

Fig 4 Pattern blocks

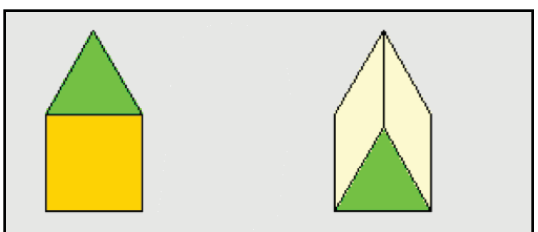

Fig 4 Congruent Pattern Block pentagons

This hands-on pattern block activity replicates how the ancient Egyptians computed areas

Building off question three, students could compare the areas of the two white rhombuses to that of the orange square. Students could conclude that the area of two white rhombuses is the same as the area of one square because the arrangements are congruent and the only other shape in both figures is one green triangle. Going a step further, students will connect that when one green triangle is removed from both arrangements, the remaining shapes are equal. These are just a few of the questions that can be posed to a middle school classroom.

This hands-on pattern block activity replicates how the ancient Egyptians computed areas since the area of one shape was used to find that of another. This parallels how they computed the area of a circle by relating it to a similarly sized square with a known area.

Concluding Remarks

Many modern mathematicians are quick to judge the Rhind papyrus on its correctness by holding it to modern standards. However, it's quite admirable that even without modern tools or values such as π, they were able to form equations that were relatively precise. It's important to recognize the context in which they were working, and accept their roundabout methods. Likewise, middle school students can use ways other than equations to gain understanding and clarity on mathematical concepts. The Rhind papyrus undoubtedly laid a strong foundation for the math we use today, so it is important and beneficial to incorporate their ideas into the classroom.

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The pattern seeking mind

"Evolution favors pattern seeking, because it allows the possibility of reducing mysteries to fast and efficient programs in the neural circuitry."

Eagleman, D. M. (2011). *Incognito: The secret lives of the brain, 139.* Pantheon Books, NY.