Algebra 2 Math Matters

Does Math Create Our Scientific Reality?

Read the attached article and answer the questions below. ***Write your answers in complete sentences on a separate sheet of paper!!!***

1. Carefully read the 4th paragraph. Explain ***in your own words*** what is meant by the statement "Without math, science would be trapped in a web of words."

2. Scientists must be able to relate symbols in equations to real world objects and quantities. What two things must be done to accomplish this?

3. The article states that mathematics is simply a matter of following rules. Argue for or against this statement.

4. Einstein made the statement "Mathematics deals exclusively with the relations of concepts to each other without consideration of their relationship to experience (the real world)." Explain what **<u>you</u>** believe he meant by this statement.

5. (a) According to the article, which is usually discovered first—the mathematics or the scientific concept?
   (b) Does this seem logical to you? Explain.
   (c) Give 2 examples stated in the article that back up this idea. Describe the science concept and the mathematics used to explain it.
   (d) Describe a science concept you have learned which depends on mathematics to explain it.

6. (a) What is an imaginary number?
   (b) Do they have a use in the real world? If so, what are they used for?

7. Consider the last paragraph. Which option do you believe is true? Explain.

8. (a) Do you believe there are relationships between math and science that have yet to be discovered? If so, suggest an area of study in mathematics or science where you believe there are more connections yet to be discovered.

Seigfried, Tom. “Does Math Create our Scientific Reality” Star-Bulletin & Advertiser 7 October 1990: E1+.

Why should mathematical methods, invented out of thin air by mathematicians long before physicists had any interest, describe nature so accurately? Nobody really knows.

There is simply something suspicious about the success of mathematics. Wigner wrote that the situation is something like trying to open a series of doors by choosing keys out of a box at random. If the first key works every time, it causes one to wonder about how locks and keys are related.

The art of science is matching mathematics to the world.

Without math, science would be trapped in a web of words. With math, scientists can usually describe what happens in the world precisely. When they say the next total solar eclipse will be visible in Hawaii on July 11, you can make your travel plans with confidence.

Scientists succeed in their endeavors because they can relate symbols in equations to real-world objects and quantities. There are two aspects of accomplishing this. One is doing the math right; the other is figuring out what the math means—relating the symbols to reality.

Getting the math right is the easy part. It’s simply a matter of following rules. After all, math is true by definition. One plus one is two because “two” is the definition of what you get when you add one to one. The rest of mathematics is built on such definitions.

The mystery is why such a system of rules for combining numbers, designed solely to be internally consistent, does such a good job of describing what goes on in the world. As Einstein once remarked, “Mathematics deals exclusively with the relations of concepts to each other without consideration of their relationship to experience.” As far as mathematics is certain, Einstein said, it does not refer to reality. When math refers to reality, it cannot be certain.

Nevertheless it works. The mathematical laws of motion and gravity and complicated equations describing the action of subatomic particles all successfully describe what happens in nature.

Perhaps this would not be so mysterious if scientists always made measurements first and then based mathematical rules to fit what was observed. But to the contrary, the mathematics often gets invented first—the physical uses come along later.

That was the case, for example, with Einstein’s general theory of relativity. In trying to figure out how to describe gravity, Einstein found the key in a mathematical system invented by Georg Riemann decades earlier.

When Werner Heisenberg was a student developing quantum mechanics in 1925, he spent a sleepless night inventing a new system of computation to describe the motion of

electrons in atoms. His professor Max Born noticed that the "new" math was merely matrix multiplication, a 19th-century invention.

Why should these mathematical methods, invented out of thin air by mathematicians long before physicists had any interest, describe nature so accurately? Nobody really knows.

Nobel laureate Eugene Wigner, who made major contributions to the mathematics of modern physics, reflected on this question in a famous paper in 1960 titled "The Unreasonable Effectiveness of Mathematics in the Natural Sciences."

"The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve," he wrote. "The enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and …there is no rational explanation for it …Fundamentally, we do not know why our theories work so well."

Wigner observed that even some of the most bizarre notions of mathematics turn out to be essential tools for physicists. Take imaginary numbers, for instance. It is easy to see that there is no such number as the square root of minus-one. No number multiplied by itself gives a negative number, as anybody who's seen the movie "Stand and Deliver" will recall.

Did that stop mathematics? No. They invented an imaginary number called "the square root of minus-one," symbolized by "i." They have developed a whole field of mathematics built around numbers containing "i" (called complex numbers, because—let's face it—they aren't simple).

For a while, complex numbers were really just mathematical amusements. But it turns out, Wigner noted, that these imaginary numbers are essential in formulating the laws of quantum mechanics. There is no way that the people inventing complex numbers could have had any clue from nature that such numbers had anything to do with reality.

"Certainly, nothing in our experience suggests the introduction of these quantities," Wigner wrote.

There is simply something suspicious about the success of mathematics. Wigner wrote that the situation is something like trying to open a series of doors by choosing keys out of a box at random. If the first key works every time, it causes one to wonder about how locks and keys are related.

Perhaps our ability to unlock the mysteries of the universe with mathematical keys is a sign that many different forms of description of nature are possible, and we have so far discovered only a few. Or perhaps all our successes so far are mere approximations to reality and a "true" picture of the world has not yet emerged.

Name_____

ALGEBRA II QUESTION-ANSWER-RELATIONSHIPS ACTIVITY
Does Math Create Our Scientific Reality?

Answer the questions below about the article "Does Math Create Out Scientific Reality."

Q1 Right There—The answer is in the text, usually easy to find. The words used to make up the question and words used to answer the question are often Right There in the same sentence.

Q2 Think and Search—Answers come from more than one sentence. You may need to put together different parts of the article to answer the question. Examples: Explain, Compare & contrast, Cause & effect, Listing examples

Q3 Author & Me—The answer is NOT in the text. You must combine your personal knowledge with information in the text to answer the question.

Q4 On My Own—The answer is NOT in the text. You can answer the question without reading the article. You answer the question based on your own experience.

Circle the letter of the best answer or answers for each question.

1. According to the article, what **two** actions must scientists accomplish in order to successfully relate symbols in equations to real-world objects and quantities?
   A. Choose appropriate letters to represent variables.
   B. Do the math right.
   C. Design new systems of computations.
   D. Figure out what the math means and relate the symbols to reality.

2. Which of the following is NOT an example given in the article of how existing mathematics was found to relate to real world events?
   A. Einstein's theory of relativity
   B. the use of imaginary numbers in the laws of quantum mechanics
   C. the use of derivatives in calculus to find the velocity of moving objects
   D. the use of matrix multiplications to describe the motion of electrons in atoms

3. The article describes the creation of a field of mathematics known as imaginary numbers. It defines the square root of negative one to be represented by i. Using this definition, what is the value of $\sqrt{-9}$?
   A. $9i$
   B. $3i$
   C. $81i$
   D. There is no value.

4. If the letter i is used to represent a mathematical value, which of the following letters is/are also used to represent a mathematical value. (There may be more than one answer.)
   A. π
   B. e
   C. $\Re$
   D. k

5. Which of the following best describes the overall idea presented in this article?
   A. As new scientific concepts are discovered, new mathematics must be created to explain them.
   B. Mathematical concepts are developed purely from a system of rules found to be true. Later, scientific concepts are found which require the earlier developed mathematical concepts to explain them.
   C. The relationship between mathematics and science is often just a coincidence.
   D. Mathematical concepts are nice but not necessary to explain most scientific concepts.