TABLE   **GRAPH**
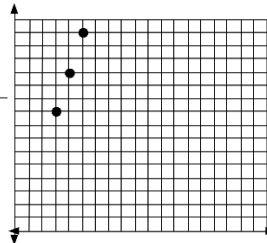
RELATIONSHIP

Justify and Critique Activity:
Algebraic Relationships in Two Variables

Overview

Current standards in mathematics require that students be able to "construct viable arguments and critique the reasoning of others" (Common Core Standards, Standards of Math Practice 3). Further, "mathematically proficient students . . . justify their conclusions, communicate them to others, and respond to the arguments of others." This activity has students justifying and making arguments for their solutions to higher-order thinking math questions, and it has students questioning or critiquing the solutions of their classmates.

This Justify and Critique activity is on the middle school mathematics content of algebraic relationships in two variables, and is aligned with *Go Math: Middle School Grade 6* (Houghton Mifflin Harcourt, 2014). The questions used in the activity are taken from the "argument-based mathematics reasoning" question set and activity, produced by Argument-Centered Education. Note that 'critique' doesn't mean exclusively 'contradict.' 'Critique' can mean agree but with a difference, a variation, or a slight difference in explanation. The important thing is that there are competing ideas in play.

Method and Procedure

(1)   Students should be put in pairs. Then each pair should be assigned another pair that they will be matched against for this activity.

(2)   Each group of four students (two pairs) should be assigned one of the higher-order
        thinking problem-pairs below:

        (A) Questions 18 & 19 (12.1, p. 336)

        (B) Questions 9 & 10 (12.2, p. 344)

        (C) Questions 13 & 14 (12.3, p. 350)

        (D) Questions 15 (12.3, p. 350) & 12 (12.4, p. 356)

        (E) Questions 13 & 14 (12.4, p. 356)

(3)   Using problem 17 (12.1, p. 336), and any of the justification and critique questions
        from the list below, the instructor should model for the students both a justification
        of their solution to this problem and a critique of that justification.

(4)   Each pair should solve both problems, and should take through their justifications for
        their solutions. If the problem calls for graphing, each pair should graph out their
        answer on paper. Each pair should also take notes for their presentation of either a
        justification of their solution to the problem, or a critique of their matched pair's
        solution.

(5)   Each higher-order thinking problem has a justification question and a critique
        question which the student pair assigned to that problem should read and be prepared
        to respond to. The questions are below, and can be printed and cut out on strips of
        paper and distributed to the appropriate student pairs.

(6)   The first group of students should then be called up to the front of the class to
        conduct their justification and critique. One pair should be selected by the instructor
        to go first answering and justifying their answer to problem 18 (12.1, p. 336). The
        other pair should then ask them the justification question, which the first pair should
        answer. Then the second pair should be asked by the instructor the critique question,
        and the second pair should answer it.

(7)   The tables are turned for the next problem, number 19 (12.1, p. 336). The second
        group should solve this problem and justify their solution. The first group should
        then ask the second the justification question. The instructor should then ask the first
        group the critique question.

(8)   Student pairs should be allowed to use a document camera, under the instructor's supervision, in order to demonstrate their work.

(9)   Each group of students should go up to the front of the class to participate in the Justify and Critique activity, in turn. Occasionally, the instructor should ask students who are observing questions to check for their understanding and to involve them in the on-going learning project.

(10)   A separate rubric can be used to assess student pairs' justification and critique and the mathematical reasoning they conducted and communicated. Or the activity can be conducted without a formal or direct assessment component.

Justification and Critique Questions for Each Problem

Problem 18 (12.1, p. 336)

Justification   Can you explain that in a different way?

Critique   Do you agree with the reasoning the other pair provided to justify
                       their answer? Was there anything missing or not exactly correct in their
                       justification?

Problem 19 (12.1, p. 336)

Justification   Can you explain your reasoning to get to your solution in a different way?

Critique   If you were to question the other pair's reasoning to get to their solution, what
                       would you focus on? How could you create a critique of their reasoning?
                       Now, ask the other pair to respond to this critique.

Problem 9 (12.2, p. 344)

Justification   What broader principle or rule does your reasoning seem to suggest is generally
                       true in math?

Critique   What do you think about what the other pair just said? How solid and
                       thorough was their reasoning?

Problem 10 (12.2, p. 344)

Justification   Is there a more efficient or clearer way to explain your answer to this problem?

Critique   Can you come up with a real-world example that more clearly demonstrates the
                       real-world instance where a relationship has no clear independent or dependent
                       variable? Why is your example clearer?

Problem 13 (12.3, p. 350)

Justification   Walk us through your steps. Where did you begin, and how did you get to the next step? Then the step after that . . . ?

Critique   Can you come up with the same answer but using a different way to justify it, a different argument for why it is true? Whose method of justifying their answer do you think is better, and why?

Problem 14 (12.3, p. 350)

Justification   Can you use your process for solving this problem and justifying your solution, but coming up with a more complex real-world situation and relationship between two quantities? Try to do that now.

Critique   Do you think that there is some aspect of the other pair's mathematical reasoning that is unnecessary, untrue, inapplicable, or unjustified?

Problem 15 (12.3, p. 350)

Justification   What broader principle or rule does your reasoning seem to suggest is generally true in math?

Critique   Would this reasoning be clear to a younger student or a person your age relatively new to math? What portion of the argument or reasoning might they not understand or not agree with, if any?

Problem 12 (12.4, p. 356)

Justification   Why did you decide to use this method (or process) of solving the problem?

Critique   Can you summarize in your own words the mathematical reasoning the other pair just described? Which statement of math reasoning – yours or theirs – do you think is clearer? Why?

Problem 13 (12.4, p. 356)

Justification   Can you explain your mathematical process to the class? Clarify for everyone
                      why it works.

Critique   Do you agree with the reasoning offered by the other pair to argue for their
                      mathematical processes? If you had to find a flaw in their reasoning, what could
                      you come up with? Now ask the other pair to respond.

Problem 14 (12.4, p. 356)

Justification   Why is your solution true?

Critique   Can you arrive at the same answer but using a different way of justifying it, or
                      argument for why it is true? Whose justification do you think is clearer or more
                      complete?