Distance, Rate, and Time—Walking Home

About Illustrations: Illustrations of the Standards for Mathematical Practice (SMP) consist of several pieces, including a mathematics task, student dialogue, mathematical overview, teacher reflection questions, and student materials. While the primary use of Illustrations is for teacher learning about the SMP, some components may be used in the classroom with students. These include the mathematics task, student dialogue, and student materials. For additional Illustrations or to learn about a professional development curriculum centered around the use of Illustrations, please visit mathpractices.edc.org.

About the *Distance, Rate, and Time—Walking Home* Illustration: This Illustration's student dialogue shows the conversation among three students who are trying to figure out when a pair of siblings will meet as they walk home from school, given different starting times and the amount of time it usually takes each to complete the journey. After using several approaches, students finally solve the problem and are left wondering why their solution is independent of the distance between the school and house.

Highlighted Standard(s) for Mathematical Practice (MP)
MP 1: Make sense of problems and persevere in solving them.
MP 2: Reason abstractly and quantitatively.
MP 4: Model with mathematics.
MP 8: Look for and express regularity in repeated reasoning.

Target Grade Level: Grades 8–9

Target Content Domain: Creating Equations (Algebra Conceptual Category), Expressions and Equations

Highlighted Standard(s) for Mathematical Content

A.CED.A.1	Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.* ★
A.CED.A.3	Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* ★
8.EE.C.8a	Understand that solutions to a system of two linear equations in two variables correspond to points of intersection of their graphs, because points of intersection satisfy both equations simultaneously.

Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards indicated by a star symbol (★).

Math Topic Keywords: rate, distance, graphing, equations, modeling

This material is based on work supported by the National Science Foundation under Grant No. DRL-1119163. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Distance, Rate, and Time—Walking Home

Mathematics Task

Suggested Use
This mathematics task is intended to encourage the use of mathematical practices. Keep track of ideas, strategies, and questions that you pursue as you work on the task. Also reflect on the mathematical practices you used when working on this task.

Two siblings—a brother and a sister—attend the same school. Walking at constant rates, the brother takes 40 minutes to walk home from school, while the sister takes only 30 minutes on the same route. If she leaves school 6 minutes after her brother, how many minutes has he traveled before she catches up to him?

Task Source: Adapted from Krutetskii, V. A. (1976). *The Psychology of Mathematical Abilities in Schoolchildren.* Chicago: University of Chicago Press.

Distance, Rate, and Time—Walking Home

Student Dialogue

Suggested Use
The dialogue shows one way that students might engage in the mathematical practices as they work on the mathematics task from this Illustration. Read the student dialogue and identify the ideas, strategies, and questions that the students pursue as they work on the task.

Students in this class have been creating linear equations from contexts and graphing those equations. They have also worked on systems of equations and understand that the intersection of two graphs is the solution to the system.

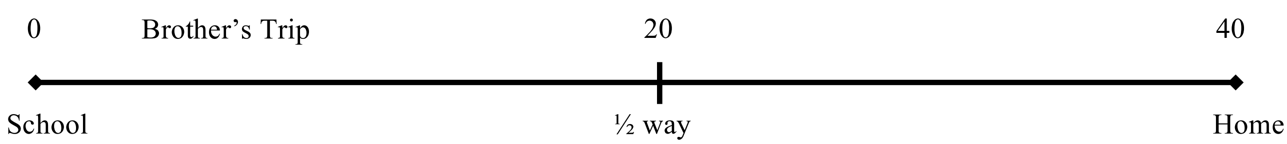
(1) Chris: All right, she takes 30 minutes and he takes 40, but how far is it from school to home?

(2) Lee: I don't know; it doesn't say. But it's the same for both of them, so maybe it doesn't matter.

(3) Chris: Well, then how do we do it?

[Students work for several minutes independently.]

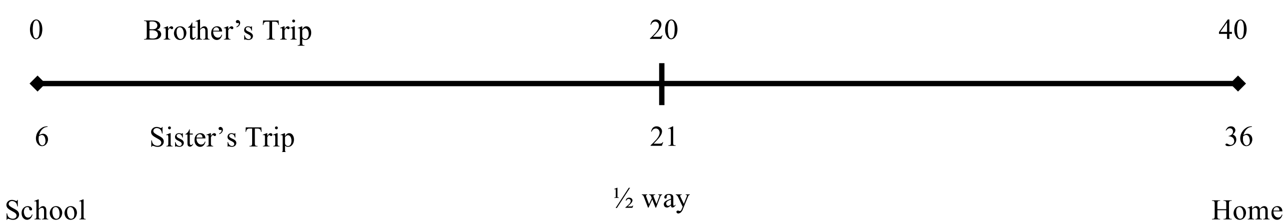
(4) Lee: Here's what I'm thinking… *[draws the following]*



If it takes him 40 minutes to get home, he is halfway at 20 minutes.

(5) Chris: Okay, so she is halfway in 15 minutes… so what?

(6) Matei: But don't forget she starts 6 minutes later… So, let's say he starts at 3 o'clock; he is halfway home at 3:20. She would start at 3:06 and be halfway at 3:21.



(7) Lee: That's pretty close… we can just keep doing that. We have to figure out when the times match!

(8) Chris: Okay, so when are they $\frac{3}{4}$ of the way home?

(9) Lee: $\frac{3}{4}$ of 40 is 30 so he is $\frac{3}{4}$ of the way home at 30 minutes. $\frac{3}{4}$ of 30 is 22.5 so that's when she is there, $22\frac{1}{2}$ minutes.

(10) Matei: That can't be right. She's halfway there at 21 minutes, but at $22\frac{1}{2}$ she's already $\frac{3}{4}$ of the way home? No way.

(11) Lee: Oh yeah. We have to add the 6 minutes, so she gets there at $28\frac{1}{2}$ minutes. So they're not together, but now she is ahead of him because she gets to $\frac{3}{4}$ of the way at $28\frac{1}{2}$ minutes, but he isn't there until 30!

(12) Matei: Good point. Okay, I have another idea, let's graph it and see what we can do.

(13) Chris: How do we graph it if we don't know the distance?

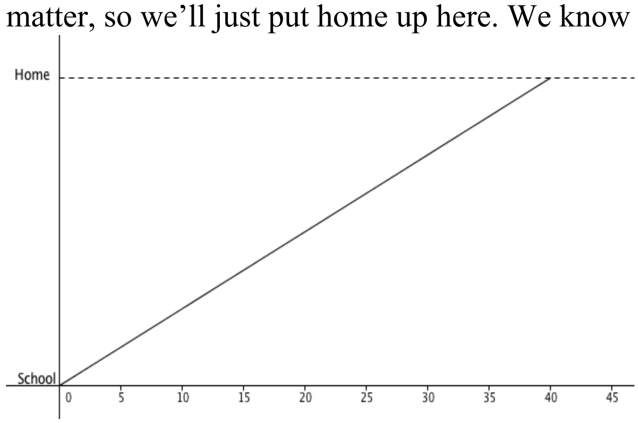
(14) Lee: Let's guess a distance – maybe it's 20 miles.

(15) Chris: Really??? 20 miles in 40 minutes? That's like supersonic or something.

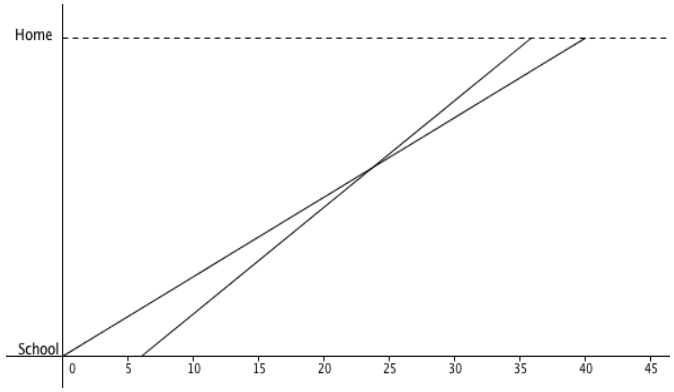
(16) Lee: Okay, you're right, not 20 miles, but maybe 2.

(17) Chris: That's better, but how does that help us?

(18) Matei: We can do something like this… *[draws the following]* If distance is on the vertical axis, then let's make 0 be the school, and let's put home… well, it doesn't matter, so we'll just put home up here. We know he takes 40 minutes to get there.



and she takes 30 but leaves 6 minutes later so she arrives at home at minute 36.



(19) Lee: Okaaaaaaayyyyy… but what can we do with this?

(20) Matei: Well, since the graphs cross, we know they meet.

(21) Chris: But we already knew that because she started behind him—6 minutes later—and she is ahead of him when she gets $\frac{3}{4}$ of the way home. Wait… it looks like they meet just before 25 minutes. But how do we check that?

[Students pause and consider the question.]

(22) Lee: Let's go back to what we were doing before. We figured out when they were at $\frac{1}{2}$ way and $\frac{3}{4}$ of the way. I think we can use that.

(23) Chris: We took $\frac{1}{2}$ of 40 to get 20. Then we took $\frac{1}{2}$ of 30 and had to add 6. These are different, so it wasn't right. Then we did the same thing—$\frac{3}{4}$ of 40 and compared that with $\frac{3}{4}$ of 30 plus 6 extra minutes.

(24) Matei: So what's changing is the portion of the trip that they've covered—you know, $\frac{1}{2}$ and $\frac{3}{4}$. So that's our variable.

(25) Chris: Okay, so it'll look like this, right? *[writes the following]*

$$40x = 30x + 6$$

(26) Lee: And if we solve that we get $\frac{6}{10}$.

(27) Matei: So they meet at $\frac{6}{10}$ of the way home… $\frac{6}{10}$ of 40 is 24 minutes and $\frac{6}{10}$ of 30 is 18 plus 6 is 24! That fits with the graph that looks like it's just before 25.

(28) Chris: So, it's $\frac{6}{10}$ of the way home no matter what the distance is. I wonder why the distance doesn't matter…

Teacher Reflection Questions

Suggested Use
These teacher reflection questions are intended to prompt thinking about 1) the mathematical practices, 2) the mathematical content that relates to and extends the mathematics task in this Illustration, 3) student thinking, and 4) teaching practices. Reflect on each of the questions, referring to the student dialogue as needed. Please note that some of the mathematics extension tasks presented in these teacher reflection questions are meant for teacher exploration, to prompt teacher engagement in the mathematical practices, and may not be appropriate for student use.

1. What evidence do you see of students in the dialogue engaging in the Standards for Mathematical Practice?

2. In line 2 of the dialogue, Lee poses that the distance doesn't matter, and in line 28, Chris agrees with this. Is this true, and how can we show that distance doesn't matter?

3. What other situations could be posed or questions pondered about these siblings' journeys home from school?

4. What other ways might students approach this problem?

5. If students have difficulty believing that this can be solved without knowing the distance, what questions could you ask that would help them get started?

Mathematical Overview

Suggested Use
The mathematical overview provides a perspective on 1) how students in the dialogue engaged in the mathematical practices and 2) the mathematical content and its extensions. Read the mathematical overview and reflect on any questions or thoughts it provokes.

Commentary on the Student Thinking

Mathematical Practice	Evidence
Make sense of problems and persevere in solving them.	This MP is fairly prevalent in most problem solving. Here, we see it throughout the students' comments and thinking. MP 1 can first be seen in students "looking for an entry point" by drawing a line diagram (also MP 4) in line 4. In line 6, Matei attaches clock times to help understand the time elapsed issue that Chris is referencing. In line 10, Matei considers the reasonableness of the answer and considers the (unstated) constraints of the problem's context. In line 15, Chris does a similar reality check. They show their perseverance by attempting a few different approaches and creating a few representations in order to clarify their understanding of the problem.
Reason abstractly and quantitatively.	The students in this dialogue demonstrate MP 2 when they move back and forth between the calculations and what the result means in the context of this task (lines 5, 6, 9, 23, 26–27). This is the de-contextualization and contextualization referenced in the practice. This is also prevalent in the creation of the equation they solve. $40x = 30x + 6$ is an abstract de-contextualization of the situation, and the solution $x = \frac{6}{10}$ has little meaning until it is brought back into the context of the problem and they understand that it means $\frac{6}{10}$ of the trip home.
Model with mathematics.	There are a few examples of modeling in this dialogue: Matei drawing a graph of the situation is one. The equation they ultimately use is another. Lee's original line diagram is also a model of the situation. Interpreting these models (lines 20 and 21) is also an important component of this MP.
Look for and express regularity in repeated reasoning.	In making some sense out of this problem (MP 1), students begin the process of repeating some calculations. Lee and Chris bring MP 8 to fruition in lines 22 and 23. Through recognizing that they were doing the same thing each time and attending to what changed and what stayed consistent, they were able to express this regularity through the equation they created (line 25).

Distance, Rate, and Time—Walking Home

Commentary on the Mathematics

The task in this Illustration is a distance-rate-time problem, which are favorites in many classrooms and textbooks. However, this is not a typical problem because it does not provide a numeric value for either the distance or the rate. Knowing either of these pieces (along with the time, which is given) would allow us to calculate the other and the problem becomes merely a matter of calculating correctly. In this particular task, however, students have to work around the fact that the distance is not provided as a numeric value and, as a result, they learn that this particular question can be answered anyway.

This task is also a wonderful example of the interconnectedness of the MPs. Lee's line diagram model (MP 4) helps the students to make an entry into solving the problem (MP 1). Through this, they begin the process of testing values and ultimately create an abstract representation of the problem (MP 2) by generalizing the calculations they used in checking their original guesses (MP 8). They then find a solution to the abstract equation and *contextualize* this number by reasoning about what that number means in this situation (MP 2).

Evidence of the Content Standards

These content standards all connect through using math to model a situation. The students create an equation in line 25, which represents their reasoning about the task (A.CED.A.1). They also recognize the constraints of the situation and interpret a solution as viable in line 27 when they check their solution (A.CED.A.3). The remaining standard (8.EE.C.8a) about understanding that the point of intersection of two graphs represents the solution to the two equations is less explicit in the dialogue, because they don't create the two equations that represent the two graphs. However it is clear that they understand that the point of intersection is the point in time and the distance at which the two siblings meet on their journey home as seen in Matei's remark in line 20.

Distance, Rate, and Time—Walking Home

Student Materials

Suggested Use
Student discussion questions and related mathematics tasks are supplementary materials intended for optional classroom use with students. If you choose to use the mathematics task and student dialogue with your students, the discussion questions can stimulate student conversation and further exploration of the mathematics. Related mathematics tasks provide students an opportunity to engage in the mathematical practices as they connect to content that is similar to, or an extension of, that found in the mathematics task featured in the student dialogue.

Student Discussion Questions

1. The students in this dialogue solve this problem without knowing the distance from school to home. Show how distance becomes irrelevant to solving this problem.

2. The students in the dialogue use the equation $40x = 30x + 6$ to solve the problem. Another student in the class could have come up with $\frac{t}{40} = \frac{t-6}{30}$. These equations are not equivalent, but both solve the problem accurately. Why does this new equation work? What does t represent? What does each side of the equation ($\frac{t}{40}$ and $\frac{t-6}{30}$) represent in the context of this problem?

3. In line 14, Lee proposes that it might be a 20-mile walk from school to home, but Chris tries to make some sense of the problem by suggesting that this speed is “supersonic.” What speed would be required to cover 20 miles in 40 minutes? What kind of vehicle would travel that speed? What is a reasonable distance for a person walking to cover in 30–40 minutes?

Related Mathematics Tasks

1. Two siblings attend the same school. The brother takes 40 minutes to walk home, while his sister takes 30 minutes. If they arrive home at the same time, what portion of the distance had he covered when she left school?

2. Two siblings attend the same school. The brother takes 40 minutes to walk home, while his sister takes 30 minutes. If they met at the halfway point, how long after he left school did she start walking home?

3. Two siblings attend the same school. On the trip to school from home, the sister walks twice as fast as the brother does and leaves 6 minutes later.
   A. Is it possible to determine at what time they meet? If so, find it. If not, explain why not.
   B. Is it possible to determine the distance at which the brother and sister meet? If so, find it. If not explain why not.

Distance, Rate, and Time—Walking Home

4. Now, the two siblings attend different schools. The sister's school is 1 mile farther from home than brother's, and she takes 50 minutes to get home while he only takes 30. If they are both walking at the same speed, find the distance to each school and the speed they are walking.

Distance, Rate, and Time—Walking Home

Answer Key

Suggested Use
The possible responses provided to the teacher reflection questions are meant to be used as an additional perspective after teachers have thought about those questions themselves. The possible responses to the student discussion questions and related mathematics tasks are intended to help teachers prepare for using the student materials in the classroom.

Possible Responses to Teacher Reflection Questions

1. What evidence do you see of students in the dialogue engaging in the Standards for Mathematical Practice?

   Please refer to the Mathematical Overview for notes related to this question.

2. In line 2 of the dialogue, Lee poses that the distance doesn't matter, and in line 28, Chris agrees with this. Is this true, and how can we show that distance doesn't matter?

   In line 18, Matei poses that we can just randomly assign some point as the distance home. To be more formal about that position, we can assign it a variable, h. In the graph Matei creates, we can assign two points for each line. For brother's trip, the points are $(0,0)$ and $(40,h)$. For sister's they are $(6,0)$ and $(36,h)$. Using these points, we can calculate the slope for each line as $\frac{h}{40}$ and $\frac{h}{30}$ respectively, which correlate to the rate each person travels in distance per minute. This could then lead to the following equations (d is the distance traveled at time t which is in minutes):

$$\begin{cases} d = \frac{h}{40}t \\ d = \frac{h}{30}(t-6) \end{cases}$$

   We solve this system by setting the two expressions on the right equal to one another.

$$\begin{aligned} &\frac{h}{40}t = \frac{h}{30}(t-6) \\ &120\left(\frac{h}{40}\right)t = 120\left(\frac{h}{30}\right)(t-6) \\ &3ht = 4h(t-6)^{*} \\ &3t = 4(t-6) \\ &3t = 4t-24 \\ &-t = -24 \\ &t = 24 \end{aligned}$$

   At the (*), when we divide by h, it shows that the distance is not relevant to the calculation. It's important to note that if $h = 0$, this step is not legal, but since h

represents the distance from school to home in this context, then $h \neq 0$. This statement is a good example of MP 2, understanding that since h represents a positive value in this context, we can legally divide by h.

3. What other situations could be posed or questions pondered about these siblings' journeys home from school?

   There are several; however, the trick is to make sure the questions are also answerable. For instance:
   - If they arrive home at the same time, what portion of the distance had he covered when she left school?
   - If they met at the halfway point, how long after he left did she start?
   - (changing the original conditions slightly) If she walks twice as fast as he does and leaves 6 minutes later, can you determine the time when they meet? If so, find it. If not, explain why not.

4. What other ways might students approach this problem?

   One similar approach could be that students begin by guessing the answer to the problem (e.g., guess that the siblings meet after he has traveled 10 minutes). He would have gone $\frac{10}{40}$ of the trip home and his sister would have only traveled 4 minutes, so she would have gone $\frac{4}{30}$ of the trip home. $\frac{10}{40} \neq \frac{4}{30}$ so they are not in the same place. A second attempt might be 20 minutes into his trip. He has traveled $\frac{20}{40}$ of the distance and she $\frac{14}{30}$. Again, not equal, so not the solution. However, this could lead to an equation (through MP 8) that looks like:

   $$\frac{x}{40} = \frac{x-6}{30}$$

   This equation is different from the one the students used in two significant ways. First, it comes from a different starting point—testing the guess of the time the siblings meet—and second (consequently), the variable represents time, *not* the portion of the distance traveled. The answer is 24, which is how many minutes he has traveled before she catches up with him. Alternatively, a student might also realize that the sister takes 3 minutes to cover the same distance as the brother does in 4 minutes. Building on the calculation that the brother and sister reach the $\frac{1}{2}$ way point at 21 and 20 minutes respectively, this student might see that 3 and 4 minutes later is 24 minutes for each.

5. If students have difficulty believing that this can be solved without knowing the distance, what questions could you ask that would help them get started?

Distance, Rate, and Time—Walking Home

This is a question that will be very situation-specific. Some questions to consider:

- When does each sibling get to the halfway point?
- Who gets to the halfway point first? $\frac{3}{4}$ point?
- What would you do if you knew the distance was 3 miles? 1 mile? 2 miles?
- How much of the trip has each one covered after the brother has traveled 10 minutes?

Possible Responses to Student Discussion Questions

1. The students in this dialogue solve this problem without knowing the distance from school to home. Show how distance becomes irrelevant to solving this problem.

   In the graph Matei creates, we can assign two points for each line. For brother's trip, the points are $(0,0)$ and $(40,h)$. For sister's trip, they are $(6,0)$ and $(36,h)$. Using these points, we can calculate the slope for each line as $\frac{h}{40}$ and $\frac{h}{30}$ respectively. This could then lead to the equations below, where d is the distance each has traveled and t is time in minutes:

$$\begin{cases} d = \dfrac{h}{40}t \\ d = \dfrac{h}{30}(t-6) \end{cases}$$

   We solve this system by setting the two expressions on the right to be equal.

$$\frac{h}{40}t = \frac{h}{30}(t-6)$$
$$120\left(\frac{h}{40}\right)t = 120\left(\frac{h}{30}\right)(t-6)$$
$$3ht = 4h(t-6)*$$
$$3t = 4(t-6)$$
$$3t = 4t-24$$
$$-t = -24$$
$$t = 24$$

   At the (*), when we divide by h, it shows that the distance is not relevant to the calculation. It's important to note that if $h=0$, this step is not legal, but since h represents the distance from school to home in this context, then $h \neq 0$.

2. The students in the dialogue use the equation $40x = 30x + 6$ to solve the problem. Another student in the class could have come up with $\frac{t}{40} = \frac{t-6}{30}$. These equations are not equivalent, but both solve the problem accurately. Why does this new equation work? What does t

represent? What does each side of the equation ($\frac{t}{40}$ and $\frac{t-6}{30}$) represent in the context of this problem?

In this new equation, t represents the number of minutes that the brother has traveled, so $t-6$ represents the number of minutes the sister has traveled. The solution to this equation is $t=24$ (which is the number of minutes the brother travels before his sister catches up). Each side of the equation represents the portion of the trip that each one has covered at time t. The equation works because when she catches up with her brother, they have covered the same portion of the trip.

3. In line 14, Lee proposes that it might be a 20-mile walk from school to home, but Chris tries to make some sense of the problem by suggesting that this speed is "supersonic." What speed would be required to cover 20 miles in 40 minutes? What kind of vehicle would travel that speed? What is a reasonable distance for a person walking to cover in 30–40 minutes?

   To cover 20 miles in 40 minutes, you would have to travel at a speed of 30 miles per hour (mph). This is not a "supersonic" speed of >768 mph (or 20 miles in approximately 100 seconds). Typically, people walk at about 3 mph or ride bicycles at about 15 mph. Cars and motorcycles easily travel 30 mph (when they're not in a school zone or rush-hour traffic). Given an average of approximately 3 mph for a person walking, it would be reasonable to expect that they could cover 1.5–2 miles in 30–40 minutes.

Possible Responses to Related Mathematics Tasks

1. Two siblings attend the same school. The brother takes 40 minutes to walk home, while his sister takes 30 minutes. If they arrive home at the same time, what portion of the distance had he covered when she left school?

   One way to think about it: If the brother takes 10 minutes longer to get home, and they arrive home at the same time, that means that the sister left 10 minutes later than her brother. After 10 minutes, the brother has traveled $\frac{10}{40}$ of the distance home—or $\frac{1}{4}$.

2. Two siblings attend the same school. The brother takes 40 minutes to walk home, while his sister takes 30 minutes. If they met at the halfway point, how long after he left school did she start walking home?

   We could approach this problem in several ways, most of which could also be used on the original task in the dialogue. However, if we reason about the problem by considering the relationship of the numbers, we realize that she takes 10 minutes less to walk home and they meet at the halfway point, so we REALLY want her to leave 5 minutes later than he does ($\frac{1}{2}$ of the 10 minute difference). It turns out this is true, and we can check it by calculating that he will be there at 20 minutes ($\frac{1}{2}$ of his time) and she will be there at 20 minutes after he leaves ($\frac{1}{2}$ of her time plus the 5 minute lag). We could also recognize that the 6-minute head start in the original problem is $\frac{6}{10}$ of the 10-minute time difference, and they meet $\frac{6}{10}$ of the way home. We can verify that this will always be the case with an equation (developed through MP8—repeatedly reasoning about what changes in each situation). If we represent the portion of the trip covered when they meet ($\frac{6}{10}$ or $\frac{1}{2}$ in the two examples) with variable a, and the sister's wait time (in minutes) by w, we can create the equation:

$$a \cdot 40 = a \cdot 30 + w$$

Solving this we get either

$$10a = w$$

or

$$a = \frac{w}{10}$$

which is consistent with our findings in the original task and the revised example.

3. Two siblings attend the same school. On the trip to school from home, the sister walks twice as fast as the brother does and leaves 6 minutes later.
   A. Is it possible to determine at what time they meet? If so, find it. If not, explain why not.
   B. Is it possible to determine the distance at which the brother and sister meet? If so, find it. If not explain why not.

A. This portion is solvable. The distance traveled (whatever it happens to be) will be the same for the two. Since $d = rt$, we can assign r to the brother's speed, which means that $2r$ is his sister's speed. If t is the amount of time he has traveled, $t-6$ represents the time she has traveled. So we get the following equation:

$$rt = 2r(t-6)$$

Since r is a speed, we know that $r \neq 0$, so we can divide by r without breaking any rules. Then we have:

$$t = 2(t-6)$$

$$t = 2t - 12$$

$$t = 12$$

So, after the brother has traveled for 12 minutes, his sister will catch up to him. This solution might beg the question, "If she travels twice as fast as he does, will she always catch up to him after he has traveled twice as long as her delay?" This might also lead to "If she travels 3 or 4 or 5 times as fast, how will that affect the time it takes her to catch up?" This is left for you to explore.

B. This problem is not solvable as written. One way to approach this problem is to follow the equation that the students create and that we have been using for other examples:

$$a \cdot b = a \cdot s + 6$$

In this equation, a is the portion of the distance traveled when they meet; b is the amount of time it takes the brother to get home; s is the amount of time it takes sister to get home; and 6 is the sister's delay. The only other piece of information we have is that she is walking twice as fast as he, so her time is $\frac{1}{2}$ of his time. So we could adjust the equation to:

$$a \cdot b = a\left(\frac{b}{2}\right) + 6$$

Manipulating this, we can get to $ab = 12$, which describes a relationship between the two variables but does not give us a solution to the distance covered when they meet.

4. Now, the two siblings attend different schools. The sister's school is 1 mile farther from home than brother's, and she takes 50 minutes to get home while he only takes 30. If they are both walking at the same speed, find the distance to each school and the speed they are walking.

To solve this problem, we *could* take the repeated reasoning approach (MP 8) that the students take in the dialogue while working on the original task. For example, we could presume that the distance to the closer school is 2 miles. The farther school is then 3 miles ($2+1$). We can calculate brother's speed by dividing distance by time (2 miles/30 minutes), which is (1 miles/15 minutes) or 4 mph. We can find sister's rate the same way (3 miles/50 minutes), which leads to a rate of something other than 4 mph. So we know the distance to the closer school is not 2 miles. We can try again with 4 miles. We make the same calculations and learn that this is not the answer. However, through these attempts we can make an equation: If d represents the distance to the closer school…

$$\frac{d}{30} = \frac{d+1}{50}$$

We can solve this to find that the distances are 1.5 and 2.5 miles, and their speed is 3 mph.

Alternatively, we could make a diagram similar to the one the students make at the beginning of the original task. In this diagram, it's visually represented that the sister covers the extra mile in 20 minutes. This tells us that the rate is 1 mile/20 minutes, which is 3 mph. From this, we can calculate the distances of 1.5 miles and 2.5 miles.