

# **Effectiveness of different tutoring types using ASSISTments**

An Interactive Qualifying Project

Submitted to the Faculty of  
Worcester Polytechnic Institute

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Degree of Bachelor of Science

By

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## Abstract

This project focuses on one main goal: to examine the data collected from my study to determine the best way for students to learn. Another goal is to decide a suitable number of skill-master problems before a questionnaire for a skill-builder, which requires student to get three problems right in a row. Each set is created with three separated sections to which students were assigned: five, seven or nine skill-master problems before the same questionnaire problem. A study was then conducted with the goal of finding a suitable number of skill-master problems to help students master a skill. Analysis from the collected data suggests that ten is a good number of problems to determine that students need a different type of help to succeed.

## Acknowledgement

I want to dedicate special thanks to Mrs. Heffernan for the carefully weekly guidance throughout the three terms. My special thanks to the ASSISTments development team for maintaining ASSISTments system, and helping us collect the data. Finally, I would like to thank the teachers and students who used our skill builders, because without them, the project would not have been possible.

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## 1. Introduction

Description	Skill
Finding the common factors of two whole numbers	6.NS.B.4-1
Finding the common multiples of two whole numbers	6.NS.B.4-2
Determining the ordering and absolute value of rational numbers	6.NS.C.7

**Table 1. Variabilized Templates for three mathematical skills**

The first phrase of this Interactive Qualifying Project (IQP) is to create a comprehensive set of variabilized templates, which involved skills for sixth graders such as finding the common factors of two whole numbers, finding the common multiples of two whole numbers, and determining the ordering and absolute value of rational numbers, as shown in the table above.

Description	Skill
Finding the common factors of two whole numbers (2 sections: experimental and control)	6.NS.B.4-1
Finding the common multiples of two whole numbers (2 sections: experimental and control)	6.NS.B.4-2
Determining the ordering and absolute value of rational numbers (2 sections: experimental and control)	6.NS.C.7

**Table 2. Problem sets with two sections for our second study**

We then set up and conduct a study based on the two given problem sets in order to determine whether five, seven or nine skill-master problems is the most effective one in helping a student master a particular skill. Our skill builder is constructed in such a way that each student would be randomly assigned within one of the three groups with five, seven or nine skill-master problem set. Next, we can compare the three groups by several factors such as the

number of students mastering a skill eventually, or the time they spent to master such skill (i.e, getting 3 questions correct in a row). By analyzing these data, we can determine which number of skill-master problems is the most effective for helping students absorb new mathematical concepts. The methodology, analysis process, and results are discussed later in the body of this report.

## **1.1. ASSISTments system**

In 2003, ASSISTments project, an intelligent tutoring system, began as an idea of Neil Heffernan and Ken Koedinger, with the funding from the US Department of Education, the Office of Naval Research and the National Science Foundation. Several thousands of students, mainly located in Maine and Massachusetts, have used ASSISTments. The word "ASSISTments" is a blend of "assistance" and "assessment". While the system effectively helps students to master over a hundred different skills, it gives teachers an effective way of quickly and easily assessing their students' performance. ASSISTments is a full function web-based teaching system that provides tutoring in various areas. Created and supported by WPI, ASSISTments allows teachers to develop and assign tutoring problems, and to access their performance in a timely manner. Below are the general instructions adopting several changes to the system in the last few months.


### **1.1.1. Problem sets Development**

When creating the problem sets, teachers could directly apply the pre-built content inside the system. Under the Builder tab, and then Folders tab, teachers can find hundreds of problems from the ASSISTments Certified Problem Sets, or the Shared Problem Sets with other teachers in Worcester. The pre-built problem sets are well organized by subjects, tutoring methods, students' grades, etc, which makes it very convenient for students or teachers to find any specific skills.

**ASSISTments** **Teacher** **Student** **Builder**


**Problem Sets** **Assistments** **Skills** **Folders**


**Problem Sets I've Built**


 [Problem Sets I've Built](#)


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**System, State, District and School Curriculum Items**

 [ASSISTments Certified](#)

 [Shared with Teachers from the State of Massachusetts](#)

 [Shared with Teachers in Worcester](#)

 [Shared with Teachers in Worcester Polytechnic Institute](#)

 [Favorites](#)

Besides, teachers have the option to build their own problem sets from scratch in order to suit their specific tutoring purposes. Under the Builder tab, and then Assistments tab, teachers can access the builder by click on the hyperlink Build New Assistment.

**ASSISTments** **Teacher** **Student** **Builder**

**Problem Sets** **Assistments** **Skills** **Folders**

Quick actions:  [Test Drive](#) [Edit](#) [New Copy](#)

 [Build New Assistment](#)

The ASSISTment builder allows the creation of two assistment types:

- Standard templates: static, all the numbers are fixed.
- Variablized templates: dynamic, including random variables, which are different each time a new instantiated Assistment is generated.

Moreover, there are many types of problem that can be created, depending on the needs:



- Fill in
- Check all that apply
- Algebra
- Multiple choice
- Rank
- Ungraded open response

The main problem is constructed in a text editor window, which also allows various types of input including images or videos. Also, there may be more than one main problem within a single Assistentment template. Different types of answers and tutoring strategies can be added under their corresponding sections by clicking on the link New Answer or New Strategy.

PRAVQ6V - Problem #549586 [Edit name](#)

[Home](#) [Print](#) [Task Order](#) [New Copy](#)

Problem Type:

[Create Intermediate problems](#)

The task currently assigned:  
[Tag Skills to Problem](#)

[New Main Problem](#) [Duplicate main problem](#)

Form Basic -

Save Problem Body

Problem Type:  answer sorting:

Problem Type changed to Multiple choice

Variables

Variables enable the creation of multiple similar problems. Variables created here are available in all problems, answers, buggy messages, hints, and scaffolds within this problem.

[New variable](#)

[ANSWERS](#) [Answers](#)

[New Answer](#)

Tutoring Strategies [Answers](#)

Title:  Type:  Enable:

[Create Strategy of choice](#)

Teachers can create a problem set which contains all the necessary problems and assistments to assign for the students. There are three options to create a new problem set, as shown below.

ASSISTments **Teacher Student Builder**

Problem Sets Assistments Skills Folders

Quick actions:  [Print](#) [Test Drive](#) [Edit](#) [New Copy](#)

[+](#) Create New Problem Set [+](#) Create New Quick-Problem Set [+](#) Create Skill Builder Problem Set

For each problem set, there are several settings to be chosen for each problem such as Problem Set Type (Linear Order, Random Order, Skill Builder or Choose Condition), and Assistent Mode (Tutor or Test) in order to fulfill the teachers' tutoring purposes.

Problem Set 1 [Edit name](#)

[Home](#) [Print](#) [Test Drive](#) [New Copy](#)

#### Problem Set Settings

Problem Set Type:  Linear Order  Random Order  Skill Builder  Choose Condition

#### Variables

Students will get questions in a random order until they demonstrate proficiency.

#### Skill Builder Limit

The number of assistments the student must get correct in a row on the same day to complete this problem set.

(Default is 3)

#### Subsequent Day Limit

The number of assistments the student can try on days after the first day of the mastery assignment.

(Default is 10)

#### First Day Limit

The number of questions a student can do in a day. Students that exceed the daily limit will be told to seek help and try again tomorrow. Teachers' reports will inform you if a student exceeds the daily limit so you can work with them individually.

(Default is 10)

#### Prior Knowledge

The number of assistments the student must get correct in a row without getting any wrong at all, to 'test out' of the assignment. If you set this to 0, this option is disabled.

(Default is 0)

[Save Variables](#)

#### Problems

Please select the problems and sub-sections to be part of this section.

PRAVQ6V - Problem #549586 Problem

Tutor

[Done adding problems](#)

Problem Source:

Insert a single Problem ID or a comma-separated list of IDs into the following form, then click "Add Problem" and the Problem will be added to the Sequence.

Problem IDs:

[+ Write New Problems Using the Builder](#)

[Advanced Options](#)

After the creation, these assistments and problem sets could be shared directly with other teachers through the system.

### 1.1.2. Problem Sets Assignment

Teachers can simply assign problem sets to students under the tab Teacher. They have the option to add a new class or edit the class information at any time by clicking on the hyperlink [Edit Class Info](#). To assign problems to a specific class, teachers have to click on the [Assignments](#) link inside their created class and choose the problem sets that they want.

Classes [View Disabled Classes](#)

[Worcester Academy \(Mar 15, 2013\)](#)

Grade: 8  
 Automatically Disable Class On: Mar 15, 2014 [disable now](#)

[Roster](#) [Edit Class Info](#) [\[+\] Class Settings](#)

[+](#) New Class

Once the problem set is assigned, teachers can set the release date and the due date according to their teaching schedule.

Class: [Worcester Academy \(Mar 15, 2013\)](#)

[Worcester Academy \(Mar 15, 2013\) Assignments](#) [Create Sub-folder](#) [Assign with ids](#) [Rename](#)

1 - N.10.8-Fraction-Multiplication (9 items) (Problem Set PSAKCE)  
 Class progress: [\[+\]](#) Not started: 1 ~ In progress: 0 ~ Complete: 0  
 Release date: October 28, 2013 06:00 AM  
 Due date: October 30, 2013 08:00 AM [Report](#) [Show Dates](#) [Move](#) [Delete](#) [Print](#) [Test Drive](#)

Release date: 2013 October 28 6 AM 00  
 Due date: 2013 October 30 8 AM 00  
[Save](#) [Remove](#)

### 1.1.3. Problem Sets View

All the students enrolling in a class can see the problem sets that were assigned to them and their due dates. They can start the problem set at any time by clicking on the corresponding link, as shown below.

ASSISTments **Teacher** Student Builder

[My Teacher's Assignments](#)

[Worcester Academy \(Mar 15, 2013\) Assignments](#)

[1 - N.10.8-Fraction-Multiplication \(9 items\) \(Problem Set PSAKCE\)](#)

Once the student clicks on the hyperlink, they will begin to work on the assigned problem set. Depending on the type of problem set that the teacher sets, different conditions are mandatory to fulfill in order to complete the assignment. For our study, all contents, which are described later in this report, are set in Skill Builder mode. It means that a student has to get three questions correct in-a-row to master a skill before moving to the next section. There is also a predetermined daily limit of number of problems a student can try, which in this case is 100.

### 1.1.4. Results Assessment

Teachers are able to access the progress of students in a timely manner. For each assignment, teachers can see several types of report.

**ASSISTments** Teacher Student Builder Account Tuan (tuanl@wpi.edu) Logout  
 Comments on Problems Messages Preferences Need help?

Select Report: [Item/Skill Builder Report](#) - [Assignment Report](#) - [Proficiency Report](#) - [Essay Grading](#) - [Unfinished Assignments Report](#) - [Assignment Completions by Date](#)

80 Student's 1 <sup>st</sup> action was to enter the incorrect answer. Student was given the correct answer.	Scaffold Student's 1 <sup>st</sup> action was to click on "Break This Problem into Steps." Student answered correctly without being given the answer.	10 Student's 1 <sup>st</sup> action was to enter the incorrect answer. Student eventually answered correctly without being given the answer.	Hint requested Student's 1 <sup>st</sup> action was to click on a hint. Student was given the correct answer.	Hint requested Student's 1 <sup>st</sup> action was to click on a hint. Student answered correctly without being given the answer.	-30 Student's 1 <sup>st</sup> action was to answer correctly.
---	--	---	--	---	--

Class: Worcester Academy (Mar 15, 2013)  
 Section: Entire Class  
 Assignment: 1 - N.10.8-Fraction-Multiplication (9 items) (Problem Set PSAKCE)  
 Automatically refresh report every 2 minutes. [Refresh Now](#)

Within each report, there are many features which the teachers can easily access to assess students. Teachers will see each student's average score as well as the class's average one. They can see the answer of each student on each individual problem, whether that answer was correct or not, and whether a student clicked on the hints or not. Moreover, teachers can see the average score of their classes on a problem by problem basis or on the overall problem set. Additionally, if there is any common wrong answer, the report displays it near the top of the page. This information could be helpful for teachers, because it allows them to see if students are making the same mistakes.

From these reports, teachers will be able to do an analysis on a specific problem or problem set for each student or the whole class. Moreover, they can acquire cumulative analysis of other useful information such as the time each student spent on a problem, the number of hints are used before each student get the problem right. Finally, the teachers can make an accurate prediction on how well a student would do on the real test.

## 1.2. Project Goals

This project has one main objective: to examine the data collected from my study to determine the best way for students to learn. I also develop additional contents for the ASSISTments system. In particular, I build problem sets for three different skills of the Common Core Mathematics Standards, targeting sixth graders. In the future, these problem sets are used to collect data for our study and enrich the overall tutoring system. The three skills are shown below.

Description	Skill
Finding the common factors of two whole numbers	6.NS.B.4-1
Finding the common multiples of two whole numbers	6.NS.B.4-2
Determining the ordering and absolute value of rational numbers	6.NS.C.7

For our study purpose, we define all students who were not able complete the skill builder right at or before seeing the questionnaire problem as the wheel spinners. In other words, those students did not succeed in mastering a skill in our expected time manner. The second objective is to conduct a study on one specific skill (6.NS.A.1) to resolve whether five, seven or nine skill-master problem set with directive feedback (i.e. with hints) is more effective in guiding students to master such skill. Thus, each problem set is created with the first five skill-master

problems having identical content and all presented to students with hints. For this skill, students are randomly assigned in either one of the three problem sets. Based on their performance, we can analyze the data and conclude which number of problems is the most efficient in helping the students to master a skill. Moreover, I can also decide how much useful the directive feedback or hints is needed for students to quickly master such skill.

## 2. Content

From the Common Core Standards, I chose three different skills for the targeting sixth graders, to construct our skill builders. Among these three skills, two are quite simple, while the other two may pose real challenges for the students. The difference in level of difficulty can introduce diversity of results in the future study we conduct later. To make solid progress and stay organized, we maintain detailed documents on Google document and spreadsheet. Every problem set is required to go through three reviewing steps to ensure the quality of my work: drafted content, built content, and approved content. The approved content will be sent out to local middle-school teachers in order to conduct the study.

### 2.1. Templates Design Process

I spent the first three weeks to familiarize myself with the ASSISTments system. During these weeks, I tried out some existing problems to see what the students will see when doing the problem sets. I then look at some problems in the edit mode to explore and understand how they were created. After that, I constructed simple problems in order to test our understanding before using the same method to create the required templates.

#### 2.1.1. The first stage

In the first stage, I focus on constructing the following two skills targeting sixth-grade students:

- 6.NS.B.4-1: Finding the common factors of two whole numbers
- 6.NS.B.4-2: Finding the common multiples of two whole numbers

I started building a drafted content for each skill, with the goal of four or more variabilized templates. At the beginning, Mrs. Heffernan provided sources and instructions on the standard structure of an ASSISTment problem as well as its hint. I learned the way to include pictures, tables and diagrams in the problems so that they can quickly convey information to the students (see **Appendix A** for more details)

During the process of building variabilized templates, I received weekly feedback from our advisor on each template on the organization, the grammar usage, and the level of difficulty. Then I made the corresponding changes according to these feedbacks. Another efficient way of improving my written problems is to get the feedbacks from other team members. Since there are four members in our team and we are all in the processing of learning about the ASSISTments system, each of us can often obtain invaluable advices.

Next, as the variabilized templates are modified based on the feedbacks received, I made some improvements about the format such as changing the text size, or coloring some texts in a hint for better visualization and emphasis purpose. They were sent to our advisor to get the final approval. If the templates are approved, they are ready to be put into the skill builder. Otherwise, I keep modifying these templates according to the feedbacks from my advisor until they are finally approved.

### 2.1.2. The second stage

As I learned a lot when building the templates during the first stage, the second stage passes quite quickly as I tackle the remaining skill:

- 6.NS.C.7: Determining the ordering and absolute value of rational numbers

The same procedure is applied for this template. I build the draft content, and modify the templates according to the weekly feedback from my advisor and the other three members. When the template is successfully built, we make some improvements in format before submitting them to obtain our advisor's final approval. They are put into the skill builder after our advisor approves. Otherwise, I keep making modifications until all the templates get the final approval.

### 2.1.3. The third stage

For each of the three skills, I create from three to four variabilized templates representing different aspects of that skill. Every template comes with detailed hints to break the problem into step-by-step explanation, which will guide the students to the final answer and strengthen their understanding on a specific skill to gradually master it. By the middle of the third term, I get all the approvals for these templates and make the skill builders based on them.

## 2.2. Problem Set Structure

I make all three problem sets to have the same structure for conveniently organizing the study and analyzing the data. Here is an example of this structure.

Dividing Mixed Numbers 6.NS.A.1 WPI [edit name](#)

[Home](#) [Print](#) [Test](#) [Drive](#) [New Copy](#)

**Problem Set Settings**

Problem Set Type:  Linear Order  Random Order  Skill Builder  Choose Condition

**Variables**

Students will get questions in a random order until they demonstrate proficiency.

**Skill Builder Limit**  
The number of assistments the student must get correct in a row on the same day to complete this problem set.  
3 (Default is 3)

**Subsequent Day Limit**  
The number of assistments the student can try on days after the first day of the mastery assignment.  
100 (Default is 10)

**First Day Limit**  
The number of questions a student can do in a day. Students that exceed the daily limit will be told to seek help and try again tomorrow. Teachers' reports will inform you if a student exceeds the daily limit so you can work with them individually.  
100 (Default is 10)

**Prior Knowledge**  
The number of assistments the student must get correct in a row without getting any wrong at all, to test out of the assignment. If you set this to 0, this option is disabled.  
0 (Default is 0)

[Save Variables](#)

Dividing Mixed Nu...	
Divide Fractions	
Divided Fractions 2	
Divide Fractions 3	

**Problems**

Divide Fractions Linear Order	<a href="#">Edit</a> <a href="#">Delete</a>
Divided Fractions 2 Linear Order	<a href="#">Edit</a> <a href="#">Delete</a>
Divide Fractions 3 Linear Order	<a href="#">Edit</a> <a href="#">Delete</a>

All problem sets, or sections, are in linear order mode; each starts with a short instruction assistment on the left, which explains the skill builder rule for the student, and ends whenever the student gets three questions correctly in a row. The main part is set in Skill Builder, which randomly assigned the students into one of the three sections with the first six skill-master problems identical. An example is shown above.

There are 100 instantiated assistments being generated from the three variabilized templates. Thus, each skill builder consists of 100 different problems of the same skill. To successfully complete a skill builder, a student has to answer correctly three problems in-a-row. A student can attempt up to a maximum of 100 problems a day.

### Problem Set Settings

Problem Set Type:  Linear Order  Random Order  Skill Builder  Choose Condition

### Variables

Students will get questions in a random order until they demonstrate proficiency.

#### Skill Builder Limit

The number of assistments the student must get correct in a row on the same day to complete this problem set.

(Default is 3)

#### Subsequent Day Limit

The number of assistments the student can try on days after the first day of the mastery assignment.

(Default is 10)

#### First Day Limit

The number of questions a student can do in a day. Students that exceed the daily limit will be told to seek help and try again tomorrow. Teachers' reports will inform you if a student exceeds the daily limit so you can work with them individually.

(Default is 10)

#### Prior Knowledge

The number of assistments the student must get correct in a row without getting any wrong at all, to 'test out' of the assignment. If you set this to 0, this option is disabled.

(Default is 0)

Finally, after three terms, I successfully create the three problem sets targeting sixth graders. We test drive all of these problem sets before sending them to the teachers at local middle schools so that they can ask their students to work on our problem sets (see **Appendix B** for more details)

### 3. “Where to put it” study

In the “where to put it” study, since the students are randomly assigned into one of the three sections with five, seven or nine skill-master problems and all of them are with detailed hints, for each section, we have to choose the first six skill-master problems exactly alike to make sure the students don't know in which sections they are. These new sections are quickly approved as they are made from the authorized templates. For example, we have a problem from the skill 6.NS.B.4-1.



Problem ID: PRAVNSN [Comment on this problem](#)

Select all numbers that are the common factors of 84 and 420.

---

Select all that apply:

21

25

1

42

37

28

Within each template in any of those three sections, step-by-step explanations are provided. There are a total of three hints as shown below, which guides the students toward the final answer and helps them understand how to find a common factor for this type of problem.

Write the factor pairs for each number 84 and 420

[Comment on this hint](#)

Here are the first three factor pairs for 84 copy these down and **finish the list.**

1, 84  
2, 42  
3, 28

Here are the first three factor pairs for 420 copy these down and **finish the list.**

1, 420  
2, 210  
3, 140

[Comment on this hint](#)

If you look at your list you will see that the two numbers that are the common factors are: 1, 28, 21 and 42

[Comment on this hint](#)

At the beginning of each skill builder is a short tutorial assistment, which gives the students the standard rule on how to complete the skill builder. Since all of the problem sets are skill builders with the same rule of completing 3 right answers in-a-row, we only need one short instruction to explain this concept to the student. This instruction is shown below.


**Answer 3 correctly in a row  
on the same day**

Moreover, we decide that each skill builder will come with a freebee (i.e, every answers will be considered correct) sixth problem as a multiple-choice questionnaire to understand the



reason why students struggle with a particular skill. This problem is set in test mode so that the students have to choose one of the given answer to either complete the whole problem set by getting 3 questions correctly in a row or continue to work on the problem set until satisfying the given rule. Students' answers on such question can provide additional information for our analysis. For example, the questionnaire item for skill 6.NS.B.4-1 is shown below.

*Problem ID: PRAVNYX* [Comment on this problem](#)



You seem to be struggling with this problem set. Which of these best describes why you're finding this hard:

---

*Select one:*

- I don't understand how to find common factors
- I don't understand how to find all the factors of a number
- I keep making silly mistakes
- I can do it but I'm bored
- None of the above

Now, I'm ready to generate instantiated assistments from these templates in order to construct the necessary problem sets for my study. Since the process consumes a lot resource from the ASSISTments server and might interfere with the connections of other people to the website, I usually perform it during the low-traffic time of the day such as after midnight.

In this study, due to the problem sets' settings, the students are randomly assigned to one of the three following sections within the skill builder: sections with five, seven or nine skill-master problems before the questionnaire, or freebee, problem. At the beginning, they all receive the instruction to get 3 right answers in-a-row in order to complete the skill builder. Finally, if they complete the skill builder either right at or after the questionnaire, we can further understand their reasons for struggling on a particular skill and use some other ways (i.e, motivational videos, detailed problem-solving instruction videos) to help them improve their understanding on such skill. The result of this study will determine how many problems before the freebee problem we should put into our problem sets before assigning them to each experimental group (students working on problems with only hints provided) and control group (students working on problems with only video instructions provided).

### 3.1. Goal

Our goal for this study is to determine if there was any pattern in releasing the questionnaire problem at the 6th, 8th or 10th position in order to determine which spot was the best. Thus, we will measure this hypothesis through the analysis on the collected data. In order to achieve the result, the students are separated in three sections, each has a different number of skill-masters problems before the freebee problem, within a skill builder: sections with five, seven or nine skill-master problems.

### **3.2. Experimental Environment**

The problem sets given to several classes were made up by Ms. Barbara Delaney and Mr. Gordon who allowed us to use the results obtained from the problem sets they were already assigning to their students to help students master a specific mathematical skill. With this, we are able to obtain different levels of students even though we focused on a specific school with specific curriculum. The teachers know about our experiment but the students participating in our study were unaware that they were participating in a study. When a teacher gives a student subject a specific skill set to master, the skill set assigned to the student will belong to one of the three sections within the skill builders. After one week, the data report is automatically collected through the ASSISTments system, thanks to Mr. Douglas Selent.

### **3.3. Data Collection**

For our study, a large amount of raw data was obtained from the ASSISTments grade book system. This data was then transferred into an Excel spreadsheet where it was filtered and organized using pivot tables. With a total of 291 students participating in the study, there are 55 problems which were done by the students. For each problem, the following information is recorded:

- First name
- Last name
- Student ID
- Teacher ID
- Teacher Log in
- Student Class ID
- Sequence ID
- Problem Log ID
- Assistentment ID
- Problem ID
- Correct
- First Action
- Hint Count
- Answer ID
- Answer Text
- Bottom Hint
- Attempt Count
- Start Time
- End Time
- First Response Time

id	assignment_id	user_id	assistent_id	problem_id	original	correct	answer_text	first_action	hint_count	bottom_hint	attempt_count	start_time	end_time	
149010821	884098	175658	414127	658636	1	1	0 15/110		0	1	0	3	12:10:32	12:11:22
149010932	884098	175658	414199	658708	1	1	1 16/25		0	0	0	1	12:11:24	12:11:40
149010961	884098	175658	414132	658641	1	1	0 15/44		0	4	1	3	12:11:40	12:14:33
149011276	884098	175658	414148	658657	1	0			1	1	0	1	12:14:33	12:15:20
149011370	884098	175658	414140	658649	1	0	0 63/630		0	3	0	4	12:15:21	19:00:05
149049228	884098	175658	537233	824089	1	1	1 I don't under		0	0	0	1	19:00:07	19:00:19
149049243	884098	175658	414139	658648	1	1	1 3/28		0	0	0	1	19:00:21	19:03:35
149049415	884098	175658	414141	658650	1	1	1 8/33		0	0	0	1	19:03:36	19:04:13
149046687	885131	175663	414127	658636	1	1	1 3/22		0	0	0	1	18:25:20	18:27:10
149046824	885131	175663	414199	658708	1	0	0 13/5		0	4	1	9	18:27:11	18:37:58
149047645	885131	175663	414132	658641	1	0	0 15/44		0	0	0	2	18:37:59	18:39:50
149047799	885131	175663	414148	658657	1	1	1 1/7		0	0	0	1	18:39:51	18:40:29
149047837	885131	175663	414140	658649	1	0	0 35/162		0	1	0	2	18:40:30	18:47:23
149048326	885131	175663	414187	658696	1	1	1 27/40		0	0	0	1	18:47:24	18:48:02
149048374	885131	175663	414149	658658	1	0	0 10/28		0	0	0	2	18:48:04	18:49:14
149048460	885131	175663	537233	824089	1	1	1 I keep makin		0	0	0	1	18:49:17	18:49:31
149048488	885131	175663	414114	658623	1	1	1 4/11		0	0	0	1	18:49:32	18:50:19
149048547	885131	175663	414198	658707	1	1	1 9/49		0	0	0	1	18:50:20	18:51:10

From ASSISTments, we can obtain the record of each student's performance on all of the problem sets they have done. These records will serve as an indicator to separate students with higher mathematical skills from other students in each class. The data is translated into another Excel file with the following information:

- Student name
- Total Problems
- Total Correct
- Correct Percentage
- Total Hint

Total Done	Total Correct	Percent Correct	Total hints
8	4	50%	10
10	6	60%	6
8	4	50%	5
11	3	27%	30

### 3.4. Assumptions

The first assumption is that in each skill builder, the difficulty levels of individual problems within each skill set are approximately equal. Therefore, the three groups within the same skill builder are exposed to the same level of difficulty and the difference in their performance is a reliable indicator for the effectiveness of where the questionnaire should be placed.

The second assumption is that the student record in each class are fairly accurate. As later, we will use these records as the indicator to separate students who were wheel spinners from those who were not in order to see the effect of the questionnaire's position on different student groups.

### 3.5. Processing the Data

#### 3.5.1. Removing unnecessary columns

The first step is to determine what data is necessary and can be used as well as what data is not. The user ID is unique, and can represent the student's first name, last name and the student class ID. Start time and End time is a good indicator for the time the problem is started and ended and will be used to see if the students only spent a reasonable time to finish their skill builders. The most important column is Correct, which is separate between different sections, including sections with five, seven or nine skill-master problems before a questionnaire problem. It is also used to determine which session a particular student was randomly assigned into based on the position of the questionnaire problems in case when they ran into it. The other columns are not necessary, and will be kept in archived.

### 3.5.2. Separate the data

Based on the position of the questionnaire problem appears in the order that the students worked on, we are able to separate the original data into three different sections with different number of skill-master problems, depending on whether the questionnaire problem's position is placed at 6<sup>th</sup>, 8<sup>th</sup> or 10<sup>th</sup> :

Questionnaire problem's position	Section with n number of skill-master problems before the questionnaire
6th	n = 5
8th	n = 7
10th	n = 9

Since the instruction assistance don't play any role in our study, we eliminate them from all the sheets. All the students who were not able to complete the skill builder before or right after seeing our questionnaire problem are moved to another Excel sheet in order to easily perform additional analysis on them. Therefore, we create in total four new Excel sheets: 3 Excel sheets for the "wheel spinners" in three sections, and 1 Excel sheet for the combination of all wheel spinners regardless of their sections.

### 3.5.3. Counting the data

Every Excel spreadsheet is filtered and sorted first by Student ID, then the Start Time so all the problems a student has done will appear in the order of occurrence. If there are three correct questions in a row before the questionnaire problem appears, it means the student successfully completed the skill builder and they are not wheel spinners, so we do not need to concern about such students. Otherwise, the student is not able to finish it. I also wanted to know the answers of the wheel spinners to our questionnaire problem, which gave us the essential information to improve our tutorial system. In addition, I counted how many problems a wheel spinner in a particular session has to go through before completing a skill builder. The total time (in seconds) a wheel spinner took to complete a skill builder is also computed. To do

that, I need to use Text to Column to remove the date from the Start time and End time, then convert the difference into seconds. Luckily, due to the small dataset, I was able to calculate those information for all students by using Excel advanced functions like SUMIFS, COUNTIFS, Custom Filter, and in some cases, I had to count manually to avoid duplicating the students already counted. This process is quite time-consuming and tedious.

The counting process took around two hours, and the result is summary in an Excel sheet as shown below. The Student ID, Self-Reflection Answers, Position of the Questionnaire problem, Complete or not a skill builder, Total number of problems, and the total time spent of each wheel spinner (in seconds) are recorded for every wheel spinners (note that the #NUM! implies the wheel spinner exited on a particular question after the questionnaire problem, hence that student did not complete the skill builder):

Student ID's	Self-Reflection's Answer	Position of the questionnaire	Complete or not a skill builder?	Total # Problems	Total time spent (in seconds)
	175658 I don't understand how to divide fractions		6 Yes	8	3213
	175663 I keep making silly mistakes		8 Yes	10	1538
	175668 Unknown	Unknown	No	1	#NUM!
	175670 I don't understand how to divide fractions		8 No	8	2495
	175876 None of the above		10 No	11	5897
	175880 Unknown	Unknown	No	2	#NUM!
	176156 I keep making silly mistakes		6 Yes	6	560
	176159 I keep making silly mistakes		10 Yes	10	2495
	176160 I don't understand how to simplify the answer		8 Yes	10	528
	176164 I keep making silly mistakes		8 Yes	13	1523
	176167 Unknown	Unknown	No	1	#NUM!
	176168 I keep making silly mistakes		10 Yes	15	2485
	176225 I don't understand how to simplify the answer		6 Yes	6	674

With this summarized datasheet, I can now perform some analysis to determine the most suitable number of skill-master problems before the questionnaire problems to actually help students master a skill. I will then put that many numbers of problems, together with the questionnaires and thirty practice problems into my other problem sets. The other team members then can use those, together with their own problem sets, to conduct an actual support study in March 2014.

### 3.6. Classify the Students

For each sections determined by the column Position of the Questionnaire, the Student ID is filtered first, then sorted by the column Total number of problems needed. For “bad performance” students who did not complete the skill builder despite seeing the questionnaire, they are marked green, and for “good performance” students who completed the skill builder at the time they did the questionnaire problem, they are marked orange. This ranking is based solely upon their performance in Assistent.

Student ID's	Self-Reflection's Answer	Position of the questionnaire	Complete or not a skill builder?	Total # Problems need	Total time spent (in seconds)
175658	I don't understand how to divide fractions	6	Yes	8	3213
176156	I keep making silly mistakes	6	Yes	6	560
176225	I don't understand how to simplify the answer	6	Yes	6	674
176233	I keep making silly mistakes	6	Yes	8	839
176238	I don't understand how to divide fractions	6	Yes	8	3055
176256	None of the above	6	Yes	6	581
176264	None of the above	6	Yes	6	634
176454	None of the above	6	No	8	#NUM!
176456	I don't understand how to simplify the answer	6	No	7	#NUM!
176459	I don't understand how to divide fractions	6	No	9	#NUM!
176462	I don't understand how to simplify the answer	6	Yes	12	4485

In order to know how many students seeing our questionnaire, I used the COUNT built-in function in Excel to count the total number of students belonging to each section. For those who was not known to belong to which section because they exited the test after doing either very few questions (1 or 2) or many questions (7 or 8) but did not see or complete the questionnaire before exiting, I also counted the total number of those students and computed the time they spent on the problem sets.

Condition	6	8	10
# of students saw the questionnaire problem	20	11	10
# of students not known which group they were in	7		
# of students saw our questionnaire problem	41		

### 3.7. Results

Condition	6	8	10
# of students saw the questionnaire problem	20	11	10
# of students not known which group they were in	7		
# of students completed after seeing our questionnaire problem	15	8	9
# of students NOT completed after seeing our questionnaire problem	5	3	1
Percentage of students NOT completed	<b>25%</b>	<b>27%</b>	<b>10%</b>

I performed several analysis on the wheel spinners within each section. First of all, I counted the number of students in each section who were able to complete the skill builder after doing the questionnaire problem, and realized that sections with 7 skill-master problems and 9 skill-master problems before a questionnaire problem appears have only 3 and 1 wheel spinners not completing the skill builder, respectively. I also calculated the percentage of wheel spinners not completing the skill builders shown in the above table.

As we may see, among the wheel spinners taking our test, there is a difference in terms of the percentage of students not completing the skill builders in sections with Condition 8 or 10 (that is, the questionnaire problem appeared at the 8th and 10th position in the problem set), despite the number of students not completing the skill builder is very close, 3 and 1 in this

case. Due to the low percentage of students not being able to finish the skill builder in Condition 10, we have the first advantage of having 9 skill-master problems before a questionnaire appears.

I also categorize the number of students based on their selected answers to the questionnaire problem, since I would like to know if the careless students are the ones who eventually finished the skill builder. If such kids did complete the skill builder, it is a good signal that Assistentment actually helps such kids improve their persistency and master a specific mathematical skill. Looking at the percentage number of students who were careless students (that is, the students whose answers were “I keep making silly mistakes” or “None of the above”), we see that almost 70% and 95% of those students continued to finally complete the skill builder. This means Assistentment did do a good job in providing the sampled students with enough practice problems so that if the students are patient enough, they will finally master a mathematical skill.

Answer	I can do it but I'm bored	I don't understand how to divide fractions	I don't understand how to simplify the answer	I keep making silly mistakes	None of the above
# of students selected the given answer and eventually completed	1	4	6	15	6
Percentage of students who completed the skill builder	100%	57%	75%	94%	67%

Furthermore, within each section, I used the AVERAGE function in Excel to calculate the average number of problems needed for wheel spinners who completed the skill builder, as well as the average number of problems needed for wheel spinners who did not complete the skill builder. The average time spent (in seconds) for students completing the skills was also computed and shown below

Condition	6	8	10
Average # problems needed to complete	7.2	11.25	11.78
Average time spent for students completing the skills (in seconds)	936	2490	2124
Average # problems Students NOT completed tried	8.4	9	11

Looking at the table above, we may realize that the wheel spinners in Condition 6 requires at least 8 problems to be able to complete the skill builders, while for those in Conditions 8 and 10, at least 12 problems were needed. This shows us that we should at least put our questionnaire problem at the 8th position. However, if we put our questionnaire at the 8th position, those wheel spinners in Condition 6 will now be in Condition 8, but the students in Condition 8 tend to require at least 12 problems, so our best solution is putting the questionnaire problem at the 10th position. The average number of problems for the wheel spinners not completing the skill builders is at least 9 in conditions 6 and 8, while it's just 11, which means one more question added in Condition 10. It shows us that the wheel spinners in the Conditions 6 and 8, are willing to try more if they did not see the questionnaire problem too early, that is not at the 6th and 8th positions. Psychologically, the questionnaire may help motivate students to try out at least one more problem.

Finally, the average time spent by the wheel spinners completing the skill builders in Condition 8 is surprisingly 1.17 times more than in Condition 10, while Condition 8 has lower percentage number of students completing the skill builders than does Condition 10. This implies that the wheel spinners only need a few extra practice opportunities before they can figure the concept out on their own and master the skill! This argument is also supported by Professors Joseph Beck and Yue Gong, who showed that the probability that the student has mastered a skill given a number of practice opportunities grows exponentially up to 10, and started growing slowly after that (see [4] for more details)

From the three arguments above, I conclude that putting the questionnaire problem at the 10th position is the optimal choice out of the three options I considered. This implies that the students will be able to benefit the most from using skill builder with 9 skill-master problems before a questionnaire problem to master a specific mathematical skill. The result of this study also helps my team obtain the optimal number of skill-master problems that need to be put into our problem sets before my teammates conduct the actual support study.

## 4. The Support Study

After determining the best number of skill-master problems we need to put before the questionnaire problem, we made the problem sets within each skill builder for two groups: experimental group (students are provided only hints when working on the three problems after the questionnaire) and control group (students are provided the instructional videos when working on the three problems after the questionnaire). In order to assign students randomly into one of the two groups without letting them figure out which group they are in, our skill-master problems are the same in either group. Therefore, each skill builder is designed with having the same first five problems, then a choose condition section that contains either the experimental or control group, and thirty practice problems so that the students will have enough problems to practice till mastering a specific skill. Here is the example of this structure.

### Questions [Edit name](#)

[Home](#) [Print](#) [Test Drive](#) [Delete Section](#)

**Problem Set Settings**

Problem Set Type:  Linear Order  Random Order  Skill Builder  Choose Condition

Change all Problems in this problem set to:

Tutor Mode  Test Mode

---

**Problems**

First Five Linear Order	<a href="#">Edit</a> <a href="#">Delete</a>
Choose Cond ChooseCondition	<a href="#">Advanced Options</a> <a href="#">Edit</a> <a href="#">Delete</a>
Practice Problem Random Order	<a href="#">Edit</a> <a href="#">Delete</a>

Within the Choose Condition section are the sections for experimental and control group. Each section will contain a different questionnaire problem, and three additional problems having the same content but different instructional tools available, depending on which group the students were randomly assigned to. The general structure of our experimental group after the students did the first five problems is following



## Experimental [Edit name](#)

[Home](#) [Print](#) [Test Drive](#) [Delete Section](#)

### Problem Set Settings

Problem Set Type:  Linear Order  Random Order  Skill Builder  Choose Condition

Change all Problems in this problem set to:

Tutor Mode  Test Mode

### Problems

Test Question Linear Order [Drag](#) [Edit](#) [Delete](#)

PRAVNTW - Common Factor\_2 Problem

[Tutor](#) [Test Drive](#) [Drag](#) [Edit](#) [Delete](#)

PRAVNSX - Common Factor\_1 Problem

[Tutor](#) [Test Drive](#) [Drag](#) [Edit](#) [Delete](#)

PRAVNVA - Common Factor\_3 Problem

[Tutor](#) [Test Drive](#) [Drag](#) [Edit](#) [Delete](#)

Note that we keep the problems in the linear order for later analysis and comparison purpose. In addition, the linear order indicates that the datasets about the students' results we will get after they do the problem sets are reliable indicators. In our experimental group, the students who need to try at least one of the problems after the questionnaire become our wheel spinners, and we care most about how they will do on those problems after receiving detailed instructional videos about a specific skill they try to master. However, in the control group, the wheel spinners only receive a "weird" questionnaire problem and the hints when working on the three problems after the questionnaire one, as shown in the two figures below

<p>Problem ID: PRAV4R7 <a href="#">Comment on this problem</a></p> <p>Worcester Polytechnic Institute (WPI) is thinking about adding sound to ASSISTments. Does the computer you are using right now have speakers?</p> <p>Select one:</p> <p><input type="radio"/> Yes</p> <p><input type="radio"/> No</p> <p><input type="radio"/> I'm not sure</p> <p><input type="button" value="Submit Answer"/></p>	<p>Problem ID: PRAV4R9 <a href="#">Comment on this problem</a></p> <p>Select all the numbers that are common factors of 84 and 420.</p> <p>Select all that apply:</p> <p><input type="checkbox"/> 2</p> <p><input type="checkbox"/> 1</p> <p><input type="checkbox"/> 6</p> <p><input type="checkbox"/> 41</p> <p><input type="checkbox"/> 31</p> <p><input type="checkbox"/> 79</p> <p><input type="button" value="Submit Answer"/> <input type="button" value="Show hint 1 of 3"/></p>
---	--

Finally, since we already created 100 instantiated problems from the three variabilized templates for each of our skill builders, we only need to choose 30 problems out of those 100 problems and put them into the practice problem session within our skill builders. Since we would like have a good mix of problems with various difficulties to interest the students, we choose 10 problems from each of the three variabilized templates. We also choose the random order for these 30 practice problems, so that the students eventually finish the skill builder because they actually master it, rather than they could detect a pattern from the given answers. Below is an example of practice problems for one of our skill builders

## Practice Problem [Edit name](#)

[Home](#) [Print](#) [Test Drive](#) [Delete Section](#)

### Problem Set Settings

Problem Set Type:  Linear Order  Random Order  Skill Builder  Choose Condition

Change all Problems in this problem set to:

Tutor Mode  Test Mode

### Problems

PRAVNST - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete
PRAVNU5 - Common Factor_3 Problem	Tuti	Test Drive	Edit	Delete
PRAVNS5 - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete
PRAVNTN - Common Factor_2 Problem	Tuti	Test Drive	Edit	Delete
PRAVNS6 - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete
PRAVNUZ - Common Factor_3 Problem	Tuti	Test Drive	Edit	Delete
PRAVNU8 - Common Factor_3 Problem	Tuti	Test Drive	Edit	Delete
PRAVNS3 - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete
PRAVNTS - Common Factor_2 Problem	Tuti	Test Drive	Edit	Delete
PRAVNU3 - Common Factor_3 Problem	Tuti	Test Drive	Edit	Delete
PRAVNS7 - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete
PRAVNS9 - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete
PRAVNTC - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete
PRAVNTR - Common Factor_2 Problem	Tuti	Test Drive	Edit	Delete
PRAVNTE - Common Factor_1 Problem	Tuti	Test Drive	Edit	Delete

In this study, due to the problem sets' settings, the students are randomly assigned to one of the two groups within the skill builder: experimental or control group. At the beginning, they all receive the instruction to get 3 right answers in-a-row in order to complete the skill builder. Finally, if they complete the skill builder either right at or after the questionnaire, we can further analyze their reasons for struggling on a particular skill based on the answers to our questionnaire problems and see if providing instructional videos will help more students master a skill than providing the word-only hints. The result of this study will determine what kinds of hints we should use for our future skill builders, for example, instructional videos or word-only hints.

## 4.1. Hypothesis

Our hypothesis for this study is to determine if instructional videos will help more students master a specific mathematical skill than word-only hints. Thus, we will measure this hypothesis through the analysis on the collected data. In order to achieve the result, the students are assigned randomly into the experimental or control group. Each group will have the same skill-masters problems before a different questionnaire problem, and followed by three additional problems with the same contents but different types of hints: instructional videos vs word-only hints.

## 4.2. Experimental Environment

Our problem sets will be given to several classes to be used by teachers who have agreed to incorporate them into their teaching plans. The teachers know about our experiment but the students participating in our study were unaware that they were participating in a study. When a teacher gives a student subject a specific skill set to master, the skill set assigned to the student

will either be of the word-only hint condition or the instructional video hint condition at random. After one term, the data report will be automatically collected through the ASSISTments system.

### 4.3. Assumptions

The first assumption is that in each skill builder, the difficulty levels of individual problems within each skill set are approximately equal. Therefore, the three groups within the same skill builder are exposed to the same level of difficulty and the difference in their performance is a reliable indicator for whether instructional videos help students master a skill better.

The second assumption is that the student records in each class are fairly accurate. As later, we will use these records as the indicator to separate students who were wheel spinners from those who were not in order to see if instruction videos have better effects on helping students master a skill than do the word-only hints.

## 5. Conclusion

For the “where to put it” study, I found out the best position at which we should put our questionnaire problem to help students maximize their chances of mastering a skill. Overall, students generally perform better when being exposed to more practice problems and given more time, because they could have sufficient experience to figure out the concepts by themselves, as long as they are determined enough to master a specific skill.

My analysis took into consideration the difficulty level of the skill set itself as well as the level of mathematical skill of the student participating in the study. It appears that some students took longer-than-expected time on some of the problems, which I expected due to various difficulty levels. Moreover, there is not much improvement for the hard-working students, but there was improvement in terms of the number of careless students completing the skill builders .

However there are various parameters that were ignored in the analysis such as bias in the data. For instance, when students click on the given hints without inputting answer, it is considered wrong but the system doesn't warn students about the scoring system which might bias data. Another constraint I had in my study was time, only 1 week to obtain the results from the assigned problem sets by Ms. Barbara Delaney and Mr. Gordon. If they could have gotten more students taking the problem sets, my conclusions would be more reliable due to having a larger sample dataset.

Moreover, the experimental environment under which Ms. Barbara Delaney and Mr. Gordon conducted might not be perfect. Although I personally hope that the students worked on the problem sets independently, they might seek for assistance from peers and teachers, which brought bias to the data. Also, there might not be enough incentive for some students to be interested in the ASSISTment system, since some students just exited ASSISTment after doing one or two problems. This might imply they didn't bring out their best performance when doing the skill builder.

In conclusion, the data obtained from ASSISTment could have been biased on either side. Assuming the equal probability of both favorable and unfavorable cases, I can safely overlook the effect of bias. This leads me to conclude that out of the three given positions (6th,8th or 10th), putting the questionnaire problem at the 10th position gives students a better chance to master a skill by themselves, which implies students using ASSISTment need a different type of help.

## References

1. About ASSISTments:  
<http://www.assistments.org/staticpages/AboutUs.htm>
2. The ASSISTments Teacher Wiki:  
<http://teacherwiki.assistment.org/>
3. The Common Core Standards:  
<http://www.corestandards.org/Math/Content/6/EE>
4. Wheel-Spinning: Students who fail to master a skill  
[Wheel Spinner.pdf](#)

## Appendix A - Template Description

Skill	Class
Find common factors	6 NS.B.4-1

Mastery Problem Set PSAJJNW	Number of Templates 3
Number to Master 3 in-a-row	Number of Attempts 100

## Templates

### PRAT3SN

*Problem ID: PRAT3SN* [Comment on this problem](#)

Select all numbers that are the common factors of 168 and 840.

\_\_\_\_\_

*Select all that apply:*

1

25

56

84

3

79

- The given numbers are between 42 and 168, and between 210 and 840
- Common factors: numbers that are factors of both given numbers

- Two variables
- Answer Type: check all that apply (4 correct answers)

### PRAUA5V

Problem ID: PRAUA5V [Comment on this problem](#)

Select all the numbers that are common factors of 84 and 420.

---

Select all that apply:

1

6

3

41

29

79

- The given numbers are between 42 and 84, and between 210 and 420
- Common factors: numbers that are factors of both given numbers
- Two variables
- Answer Type: check all that apply (3 correct answers)

### PRAUA5W

Problem ID: PRAUA5W [Comment on this problem](#)

Select all the numbers that are common factors of 42 and 210.

---

Select all that apply:

9

23

37

7

29

17

- The given numbers are between 42 and 84, and between 210 and 420
- Common factors: numbers that are factors of both given numbers
- Two variables
- Answer Type: check all that apply (1 correct answer)

Skill	Class
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Find common multiples	6 NS.B.4-2
-----------------------	------------

Mastery Problem Set PSAJJPF	Number of Templates 3
Number to Master 3 in-a-row	Number of Attempts 100

## Templates

### PRAT3SX

Problem ID: PRAT3SX [Comment on this problem](#)

Select all numbers that are common multiples of 6 and 36.

---

Select all that apply:

108

72

180

144

46

55

- The given numbers are between 6 and 18, and between 36 and 216
- Common multiples: numbers that are multiples of both given numbers
- Two variables
- Answer Type: check all that apply (4 correct answers)

### PRAVGVH

Problem ID: PRAVGVH [Comment on this problem](#)

Select all numbers that are common multiples of 20 and 6.

---

Select all that apply:

197

300

360

900

66

340

- The given numbers are between 20 and 40, and between 2 and 6
- Common multiples: numbers that are multiples of both given numbers
- Two variables
- Answer Type: check all that apply (3 correct answers)

### PRAVGU3

*Problem ID: PRAVGU3* [Comment on this problem](#)

Select all numbers that are common multiples of 6 and 50.

---

*Select all that apply:*

600

350

60

57

102

1500

- The given numbers are between 3 and 6, and between 10 and 50
- Common multiples: numbers that are multiples of both given numbers
- Two variables
- Answer Type: check all that apply (2 correct answers)

Skill	Class
Ordering of numbers and absolute values	6 NS.C.7-2

Mastery Problem Set PSAJMQP	Number of Templates 3
Number to Master 3 in-a-row	Number of Attempts 100

## Templates

**PRAUBYP**

Problem ID: PRAUBYP

[Comment on this problem](#)

Demon Valley has the elevation at 205 ft. below sea level. The elevation of Angel Hill is 1827 ft. above sea level. What is the upward change in elevation in feet from Demon Valley to Angel? Remember, sea level has an elevation of 0 ft.

\_\_\_\_\_

Type your answer below (mathematical expression):

Submit Answer

Show hint 1 of 3

- 
- The given numbers are between 200 and 209, and between 1800 and 1829
  - Upward change: distance from a lower point to a higher point
  - Two variables
  - Answer Type: Fill in

**PRAUE3Q**

Problem ID: PRAUE3Q

[Comment on this problem](#)

Fish of Type A live at 209 ft. below sea level while Fish of Type B live at 1826 ft. below sea level. What is the upward change in elevation in feet from Type B fish to Type A fish? Remember, sea level has an elevation of 0 ft.

\_\_\_\_\_

Type your answer below:

Submit Answer

Show hint 1 of 3

- 
- The given numbers are between 200 and 209, and between 1800 and 1829
  - Upward change: distance from a lower point to a higher point
  - Two variables
  - Answer Type: Fill in

**PRAUE3R**



Problem ID: PRAUE3R [Comment on this problem](#)

Bird of Type A flies at 1807 ft. above sea level. Bird of Type B flies at 207 ft. above sea level. What is the upward change in elevation in feet from Type B bird to Type A bird? Remember, sea level has an elevation of 0 ft.

\_\_\_\_\_

Type your answer below:

Submit Answer Show hint 1 of 3

- The given numbers are between 200 and 209, and between 1800 and 1829
- Upward change: distance from a lower point to a higher point
- Two variables
- Answer Type: Fill in

## Appendix B - Problem Set Summary

Skill	Class
Find common factors	6 NS.B.4-1

### 1) Problem #500196 "PRAT3SN - Common Factor\_1"

Select all numbers that are the common factors of  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .

#### Check all that apply:

- $\%v\{\text{number1}/3\}$
- 1
- $\%v\{\text{number4}\}$
- $\%v\{\text{number1}/2-5\}$
- $\%v\{\text{number3}\}$
- $\%v\{\text{number2}/10\}$

#### Hints:

- Write the factor pairs for each number  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$
  - Here are the first three factor pairs for  $\%v\{\text{number1}\}$  copy these down and **finish the list.**
- 1,  $\%v\{\text{number1}\}$   
 2,  $\%v\{\text{number1}/2\}$   
 3,  $\%v\{\text{number1}/3\}$

Here are the first three factor pairs for  $\%v\{\text{number2}\}$  copy these down and **finish the list**.

- 1,  $\%v\{\text{number2}\}$
- 2,  $\%v\{\text{number2}/2\}$
- 3,  $\%v\{\text{number2}/3\}$

- If you look at your list you will see that the two numbers that are the common factors are: 1,  $\%v\{\text{number1}/3\}$ ,  $\%v\{\text{number3}\}$  and  $\%v\{\text{number2}/10\}$

## 2) Problem #507272 "PRAUA5W - Common Factor\_3"

Select all the numbers that are common factors of  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .

**Check all that apply:**

- $\%v\{\text{number3}\}$
- $\%v\{\text{number1}-5\}$
- $\%v\{\text{number4}\}$
- $\%v\{\text{number1}-13\}$
- 9
- $\%v\{\text{number1}-19\}$

**Hints:**

- Write the factor pairs for each number  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$
- Here are the first three factor pairs for  $\%v\{\text{number1}\}$  copy these down and **finish the list**.
  - 1,  $\%v\{\text{number1}\}$
  - 2,  $\%v\{\text{number1}/2\}$
  - $\%v\{\text{number3}\}$ ,  $\%v\{\text{number1}/\text{number3}\}$

Here are the first three factor pairs for  $\%v\{\text{number2}\}$  copy these down and **finish the list**.

- 1,  $\%v\{\text{number2}\}$
- 2,  $\%v\{\text{number2}/2\}$
- $\%v\{\text{number3}\}$ ,  $\%v\{\text{number2}/\text{number3}\}$

- If you look at your list you will see that the only common factor is:  $\%v\{\text{number3}\}$

## 3) Problem #507271 "PRAUA5V - Common Factor\_2"

Select all the numbers that are common factors of  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .

**Check all that apply:**

- $\%v\{\text{number3}\}$
- 1
- 6

- ✗  $\sqrt{\text{number1}/2-1}$
- ✗  $\sqrt{\text{number4}}$
- ✗  $\sqrt{\text{number1}-5}$

**Hints:**

- We write the factor pairs for each number  $\sqrt{\text{number1}}$  and  $\sqrt{\text{number2}}$
- Here are the first four factor pairs for  $\sqrt{\text{number1}}$  copy these down and **finish the list**.  
 1,  $\sqrt{\text{number1}}$   
 2,  $\sqrt{\text{number1}/2}$   
 3,  $\sqrt{\text{number1}/3}$   
 6,  $\sqrt{\text{number1}/6}$

Here are the first four factor pairs for  $\sqrt{\text{number2}}$  copy these down and **finish the list**.

- 1,  $\sqrt{\text{number2}}$
- 2,  $\sqrt{\text{number2}/2}$
- 3,  $\sqrt{\text{number2}/3}$
- 6,  $\sqrt{\text{number2}/6}$

- If you look at your list you will see that the three numbers that are the common factors are: 1,  $\sqrt{\text{number3}}$ , 6

**4) Problem #547480 "PRAVNYX - Self-Reflection-Common factors"**

You seem to be struggling with this problem set. Which of these best describes why you're finding this hard:

**Multiple choice:**

- ✓ I don't understand how to find common factors
- ✓ I don't understand how to find all the factors of a number
- ✓ I keep making silly mistakes
- ✓ I can do it but I'm bored
- ✓ None of the above

Skill	Class
Find common multiples	6 NS.B.4-2

**1) Problem #500205 "PRAT3SX - Common Multiple\_1"**

Select all numbers that are common multiples of  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .

**Check all that apply:**

- $\%v\{3*\text{number2}\}$
- $\%v\{2*\text{number2}\}$
- $\%v\{5*\text{number2}\}$
- $\%v\{4*\text{number2}\}$
- $\%v\{\text{number2}+10\}$
- $\%v\{\text{number2}+19\}$

**Hints:**

- Write the multiples for each number  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .
- Here are the first three multiples for  $\%v\{\text{number1}\}$  copy these down and **continue the list up to  $\%v\{5*\text{number2}\}$** .

$\%v\{\text{number1}\}$ ,  $\%v\{\text{number1}*2\}$ ,  $\%v\{\text{number1}*3\}$

Here are the first three multiples for  $\%v\{\text{number2}\}$  copy these down and **continue the list up to  $\%v\{5*\text{number2}\}$** .

$\%v\{\text{number2}\}$ ,  $\%v\{\text{number2}*2\}$ ,  $\%v\{\text{number2}*3\}$

- If you look at your list you will see that the common multiples are:  $\%v\{2*\text{number2}\}$ ,  $\%v\{3*\text{number2}\}$ ,  $\%v\{4*\text{number2}\}$  and  $\%v\{5*\text{number2}\}$

**2) Problem #542569 "PRAVGVH - Common Multiple\_2"**

Select all numbers that are common multiples of  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .

**Check all that apply:**

- $\%v\{\text{number4}*60\}$
- $\%v\{\text{number3}*100\}$
- $\%v\{\text{number2}*50\}$
- $\%v\{17*\text{number1}\}$
- $\%v\{\text{number2}*11\}$
- $\%v\{10*\text{number1}-3\}$

**Hints:**

- Write the multiples for each number  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .
- Here are the first five multiples for  $\%v\{\text{number1}\}$  copy these down and **continue the list up to 900**.

$\%v\{\text{number1}\}$ ,  $\%v\{\text{number1} * 2\}$ ,  $\%v\{\text{number1} * 3\}$ ,  $\%v\{\text{number1} * 4\}$ ,  $\%v\{\text{number1} * 5\}$

Here are the first five multiples for  $\%v\{\text{number2}\}$  copy these down and **continue the list up to 900**.

$\%v\{\text{number2}\}$ ,  $\%v\{\text{number2} * 2\}$ ,  $\%v\{\text{number2} * 3\}$ ,  $\%v\{\text{number2} * 4\}$ ,  $\%v\{\text{number2} * 5\}$

- If you look at your list you will see that the common multiples are:  $\%v\{\text{number4} * 60\}$ ,  $\%v\{100 * \text{number3}\}$  and  $\%v\{\text{number2} * 50\}$

### 3) Problem #542555 "PRAVGU3 - Common Multiple\_1"

Select all numbers that are common multiples of  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .

**Check all that apply:**

- $\%v\{\text{number4} * 75\}$
- $\%v\{\text{number3} * 100\}$
- $\%v\{7 * \text{number2}\}$
- $\%v\{17 * \text{number1}\}$
- $\%v\{\text{number2} + 10\}$
- $\%v\{10 * \text{number1} - 3\}$

**Hints:**

- Write the multiples for each number  $\%v\{\text{number1}\}$  and  $\%v\{\text{number2}\}$ .
- Here are the first five multiples for  $\%v\{\text{number1}\}$  copy these down and **continue the list up to** .

$\%v\{\text{number1}\}$ ,  $\%v\{\text{number1} * 2\}$ ,  $\%v\{\text{number1} * 3\}$ ,  $\%v\{\text{number1} * 4\}$ ,  $\%v\{\text{number1} * 5\}$

Here are the first five multiples for  $\%v\{\text{number2}\}$  copy these down and **continue the list up to** .

$\%v\{\text{number2}\}$ ,  $\%v\{\text{number2} * 2\}$ ,  $\%v\{\text{number2} * 3\}$ ,  $\%v\{\text{number2} * 4\}$ ,  $\%v\{\text{number2} * 5\}$

- If you look at your list you will see that the common multiples are:  $\%v\{\text{number4} * 75\}$  and  $\%v\{100 * \text{number3}\}$

### 4) Problem #547481 "PRAVNYY - Self Identify Question-Common multiples"



You seem to be struggling with this problem set. Which of these best describes why you're finding this

hard:

**Multiple choice:**

- ✓ I don't understand how to find common multiples
- ✓ I don't understand how to find a multiple of a number
- ✓ I keep making silly mistakes
- ✓ I can do it but I'm bored
- ✓ None of the above

Skill	Class
Ordering of numbers and absolute values	6 NS.C.7-2

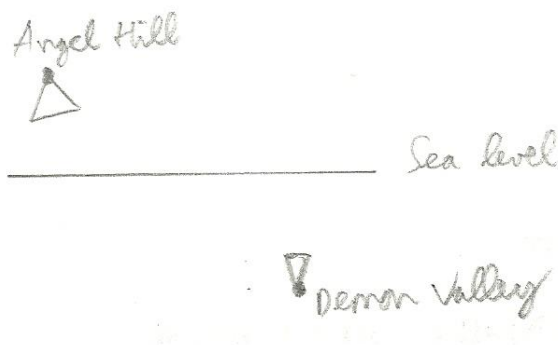
**1) Problem #508071 "PRAUBYP - 6 NS.C.7-2"**

Demon Valley has the elevation at  $\%v\{\text{number1}\}$  ft. below sea level. The elevation of Angel Hill is  $\%v\{\text{number2}\}$  ft. above sea level. What is the upward change in elevation in feet from Demon Valley to Angel? Remember, sea level has an elevation of 0 ft.

**Algebra:**

- ✓  $\%v\{\text{number2} + \text{number1}\}$

**Hints:**



- There are  $\%v\{\text{number1}\}$  ft. below and  $\%v\{\text{number2}\}$  ft. above the sea level. You need to find the number of feet in the gap between Demon Valley and Angel Hill.
- The gap is equal to  $\%v\{\text{number2}\} - (\%v\{-\text{number1}\}) = \%v\{\text{number2} + \text{number1}\}$

**2) Problem #511048 "PRAUE3Q - 6 NS.C.7-2.2"**

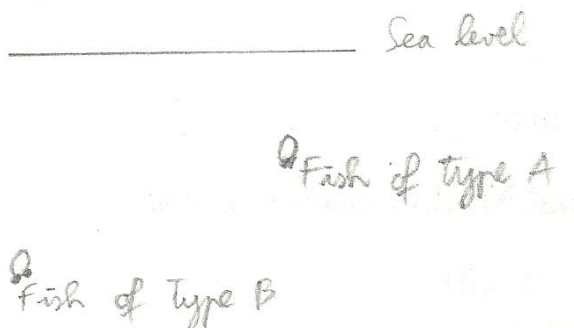
Fish of Type A live at  $\%v\{\text{number1}\}$  ft. below sea level while Fish of Type B live at

$\%v\{\text{number2}\}$  ft. below sea level. What is the upward change in elevation in feet from Type B fish to Type A fish? Remember, sea level has an elevation of 0 ft.

**Fill in:**

✓  $\%v\{\text{number2} - \text{number1}\}$

**Hints:**



- There are  $\%v\{\text{number1}\}$  ft. and  $\%v\{\text{number2}\}$  ft. below the sea level, so there's a gap between the places where Type A fish and Type B fish live.
- The gap is equal to  $\%v\{\text{number2}\} - \%v\{\text{number1}\} = \%v\{\text{number2} - \text{number1}\}$

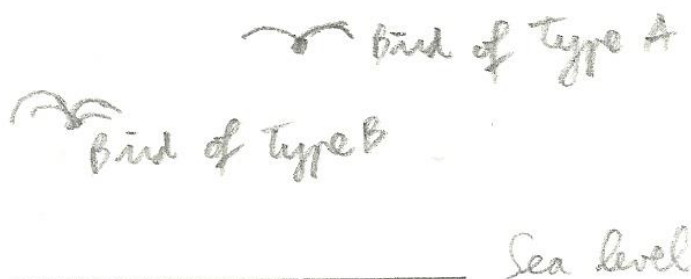
**3) Problem #511049 "PRAUE3R - 6 NS.C.7-2.3"**

Bird of Type A flies at  $\%v\{\text{number2}\}$  ft. above sea level. Bird of Type B flies at  $\%v\{\text{number1}\}$  ft. above sea level. What is the upward change in elevation in feet from Type B bird to Type A bird? Remember, sea level has an elevation of 0 ft.

**Fill in:**

✓  $\%v\{\text{number2} - \text{number1}\}$

**Hints:**



- There are  $\%v\{\text{number1}\}$  ft. and  $\%v\{\text{number2}\}$  ft. above the sea level, so there's a gap between the places where Type A bird and Type B bird fly.
- The gap is equal to  $\%v\{\text{number2}\} - \%v\{\text{number1}\} = \%v\{\text{number2} - \text{number1}\}$