A Study on the Effect of using Fantasy to Motivate and Engage Students

Interactive Qualifying Project Report completed in partial fulfillment

of the Bachelor of Science degree at

Worcester Polytechnic Institute, Worcester, MA

May 1, 2012

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Abstract

This report is about trying to find a way to improve how students learn math in games. We created a game and used fantasy as a way to get students interested in the material we were teaching them. Overall the game was successful as a proof of concept. Most students who played the game enjoyed it, even if they didn't like math in the first place, and almost all of the students said that they felt more comfortable with the topic we taught after having played the game.

Executive Summary

Computer games have been part of our culture for decades. As the media has expanded, their use has grown beyond pure entertainment. Education is one field games have expanded to. Research is being done in the field of improving education through the use of games as a teaching tool. There are many components to an educational game that could prove useful to improving education through games. The area that we decided to explore in this was how the illusion of fantasy affects learning.

The theory we were testing was that fantasy is something that draws students into a game. As they were drawn into the game with a story or something similar, they could also be learning math. The math, integrated into the story itself, could help improve the student's motivation to do the math problems and learn the concepts. One concept we tried in our play-test was having the problems start out more specific, in the fantasy environment. The hope was that the students would be able to solve the problems without resorting to teaching them the math terms. The math terms and more abstract problems would be introduced progressively as the problem set went on, hopefully allowing students to more easily understand the concepts gradually.

To test these theories, we constructed a prototype game section. In this game section, the student was asked to save 4 Villages from a dragon. To protect the villagers from the dragon, the student needed to calculate the amount of magic that it would take to cast a fire-protection spell on the villagers' houses. These Villages, also called nodes in our design, were trying to teach students the concept of surface area. They started with a section on area before working into the area of rectangular prisms and square pyramids.

To play-test the game, the four-village demo was brought to two classes of middle school students. They were given a certain amount of time in each node to solve the problems. The times were

based on the play-tests of the group. Each class was made up of 12 students. The first class consisted of students who sometime struggled in math, while the second class was an advanced math class. The students were split up into smaller groups and each given some one check their answers as they progressed through the nodes. The first node was timed by how long it took to finish; while the next village was timed by how long each problem inside the node took. After completing the four villages, each student was given a survey and time to ask any question or give opinions on what they thought about the game.

While all students from both classes were able to get one hundred percent on the first village, the next nodes showed an increasing divide. Ten of twelve students from the first class were unable to pass the second node, while six of twelve from the second class did not complete enough problems. In the third node, the first class still had nine out of twelve unable to complete sixty-five percent of the problems, but eight of twelve from the second class were able to complete enough problems to pass. The last node was the most difficult by the result, as only one student from the first class was able to pass and only three from the second class completed enough problems to pass.

From the survey, students answered favorably about the story, stating it as their favorite part of the game in most cases. This shows some promise for our hypothesis. More studies in the area could prove useful in improving upon the design of our game and also the ideas behind it. From the data, the project overall seems to support the hypothesis that we made about improving learning and motivation for work through introducing fantasy elements in a game-like environment.

Acknowledgements

There are a couple people we would like to acknowledge for their help in the completion of this project.

First we would like to thank Mr. Burnett, who allowed us to play-test our game with two of his classes so that we could gather data for our project.

Last we would like to thank Professor Beck, without whom this project would never have happened. He provided us with a lot of help throughout our project, especially when it came to the development of the game.

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Chapter 1: Introduction

Mathematics is one subject that everyone should know and is one that predates written history. It can be used to solve many basic life issues, like how much food is required to feed a family or how much clothing one needs to bring on vacation. There are many ways for this subject to be taught to younger generations who do not know math. The most common way for children to learn math is in schools, from teachers. Each year the students learn a set of math principles from their teachers which are a continuation of concepts learned from the previous year. One issue with this system is that if the students do not properly learn a math principle one year, it can negatively influence their learning in later years. This issue can be caused by several different reasons, but one important one is a lack of interest in the subject. It makes it a lot more difficult for someone to learn a concept if they cannot connect or find a reason to be interested in it.

Video games and school books are available all over the country. Stores that sell video games or school books can be found in every state. Kids will go into video game stores and buy games whenever they want to, as long as they enough money. Most kids will not go into a store and buy a book for school unless they are forced to by their parents and/or teachers. The difference between schoolwork and games for kids is the interest factor: more kids are interested in playing video games than they are in learning subjects taught in school. Kids learn the rules of games quickly because they are interested in the games and want to be able to beat them. Kids learn material taught in school at slower paces because they generally are not interested in the material being taught. It is believed that one way to get kids to become more interested in learning is by integrating games, which kids find entertaining, with learning. The purpose of this project is to develop a game that will help Seventh grade students learn math when used in addition to a teacher's curriculum. This area of research has been selected for the

WPI Innovation competition for two years in a row (personal communication, Joseph Beck, 2012), showing that there is interest in using games to help children learn math skills.

Creating a game that interests the majority of children is difficult. No single genre can interest every child, so the game had to be created so as to be seen as fun for the majority of children. The goal is to reach the middle ninety percent of children, from five to ninety five percent, since the upper five usually motivate themselves to learn and the lower five need more help than a game can provide. Research was done on what general genre kids enjoy and the group consensus was that a fantasy element would be most effective, especially when mixed with reality. By integrating fantasy and reality, we planned to teach math concepts first as rules of a game and then slowly replace the game rules as math rules. We hope that this method will help the kids learn the material without realizing that it is schoolwork until we introduce the revelation that the fantasy can be applied to real life.

As a proof of concept, we created a game to show to seventh grade students. The purpose of the game is to test how well the fantasy into reality and disguising the rules of math ideas worked when applied to actual students. Playing the game will give us an idea of how well our concepts teach the students the topic based upon the scores received by the students. Each node, or Village as they are known in the game, will be scored based on the percent of how many problems were completed versus how many problems there were in total in the time limit given. This percentage will allow us to gauge how well the game taught each student the topic, which Villages worked best, and which ones need improvement on. After the game is played the scores were calculated and graphed to show the scores students received in each Village and see if there are any trends between the scores the students received. The students also filled out a survey which was used to see which parts of the game the children liked and disliked and what they thought could improve the game for future use.

Chapter 2: Background

2.1 How students learn

To begin examining a particular method for teaching students math through a computer game, it is important to research how students learn. Understanding how students learn in the classroom is critical when determining a strategy that works alongside classroom learning. Teaching methods utilized in the classroom can then be adapted into a gaming situation, which helps to facilitate math learning in a new and interesting way.

Learning is an essential aspect of every person's life, due to the fact that we are not born knowing the information. Not just information for school topics, but for most things in our daily lives, we had to be taught, we were born not knowing neither how to brush our teeth nor how to solve math problems (Devlin, 2006). However different those two actions may be, the process of learning them is not too different, we first had to learn the basics. Devlin's theory on learning is that the skills are learned by first mastering the practice without fully understanding the concepts behind them. In this way there are steps to learning everything in life, first following a procedure and slowly becoming more proficient at it until following the procedures becomes natural and automatic and finally understanding of the skill is reached. This only enforces the idea that students have to learn the basics first, as a lack of simple skills in subjects would halt any further learning of those subjects.

This theory of how people learn skills was helpful in determining how to develop the proof of concept. Since students learn by first mastering a set of skills, the progression of the game had to include a system which built upon itself. Concepts which were not properly introduced by their building blocks would not be understood by students. As the project was based on learning math, problem sets in the proof of concept included sections which students should theoretically have been taught earlier in

their education, yet to ensure understanding of the new concept it was important to remind students of the simple procedures used which are part of the complex topic. In this way students were able to build off of previously learned skills to understand a new topic. The mathematical terms are also slowly added to the concepts that the students will have started learning to facilitate a connection between the fantasy skills with concepts they are learning in the classroom.

While many skills are learned in the same way, there comes a point where not every subject can be taught using the same methods for every student. Students understand math differently. Not every student can be expected to reach the same level of competency for every subject. While pattern-based learning may enhance understanding of topics by first introducing them as procedures, not every student will automatically see the connection between the procedure and the skill being taught. In a *The Times Educational Supplement* article, one teacher discussed the different methods he uses to teach his students. The teacher explains that there are not necessarily correlations between a student being good at memorizing multiplication times-tables and being skilled at math as long as the material has been presented to the students in a way they can process (Gale, 2011). While many may see students who are not as adept at a particular skill, such as multiplication times-tables, those students just need to be given the opportunity to see the patterns. Students who do not seem as skilled at memorizing multiplication tables usually have the ability to see patterns and solve problems.

The teacher's strategy of involving students in a fun way is very similar to the subject of this project. Developing the game needed to ensure that the questions asked were done with varied wordings to engage both types of students. By varying the wording of similar problems, the students would have a chance to deepen their understanding of the topic without just copying the previously learned procedure.

Mathematics has another disadvantage when it comes to keeping students attention, relation to the real world. Subjects like literature or science have easy connections to what is happening around students, yet the procedure and repetition that is required for math loses the interest of students (Lahoud, 2011). Effective math teaching requires students to be presented with tasks that engage their minds in determining proper strategies. In the article by Lahoud, the correlation between the students disinterest in the subject and the level of difficulty was explored. It was pointed out that a different approach to teaching the content heavy math topics was needed, one which was flexible in how to present the topics, instead of the typical repetitious practice.

While this theory was helpful in determining that math needed to be presented to students in a relatable way, it brought up a problem with the repetitious nature of the project. The fantasy storyline creates a vehicle for students to relate to math concepts, but it also requires many similar problems to be solved. The project direction was to continue with the process repeating style, which students would be familiar with from the classroom and skill learning, and has the added benefit of using fantasy to create a more relatable teaching method.

2.2 Game-based learning

While the first video games were created in the 1950s, it wasn't until the 1980s that educational games came to the mainstream and were used in the classroom. Some early games include *Jump Start*, *Math Blaster!*, *Reader Rabbit,* and *Where in the World is Carmen Sandiego?* These games have been re-released many times over the years, usually with little to no content change. Although these games were used in some classrooms, researchers in the field feel that educational games can be a more prominent tool for teaching students.

Educational game developers have been attempting to improve upon this process for years. Research has been done about what make games a good learning device and how to utilize it properly. There are several components of a game that could potential be integral to games being an improved method of learning for students.

One very important part of games is their interactivity. That is what sets them apart from books and movies and other forms of media. The interactivity is also what makes them a viable educational tool. Allowing the students to interact with the game allows them to have input, such as inputting answers to problems. This interactivity is vital to exploring games as an educational tool.

Another part of games that could be useful in educational games is the instant feedback. While doing paper and pencil problems, a student might not know for some time how they are doing on the problems, and how much they know about the topic. With games, there is an instant feedback on if their answer is correct or not.

Making games that both educate and are interesting or fun to play is something that has been researched for years. Some games, such as the ones listed in the previous section, worked, but did not make it into most classrooms. A game that is proven to improve learning could do better in the market and in classrooms. There are several things that must be kept in mind when creating edutainment games that are not necessarily true of other games.

Self-efficacy as it relates to video games is how confident the player is in their abilities to play the game. While this is an important part of entertainment games, it is an even more important part of educational games. Players who are have a higher self-efficacy than others are at an immediate advantage to solving the problems that they are given as well. Educational game designers need to be able to make self-efficacy towards the game have no effect on how the student is able to learn the material and apply their knowledge. This will allow players to focus not on how they are playing the

mechanics of the game but on the content of the game. Self-efficacy has been shown to improve how well students are doing on game-like problems, as well as how motivated they are to do the problems (Palvas, 2010).

When designing a game, flow is another gameplay attribute that improves knowledge and motivation (Palvas 2010). Flow is how the goals, feedback, balance of difficulty, control, and motivation fit together. Flow has been shown to be directly related to learning and motivation. The better a game's flow, the more that can be learned from the educational game. This means that it is important to connect all these pieces of the game describe in the definition of flow.

Fantasy is a common theme seen in many games. It makes sense that some educational games would include elements of fantasy as well. In educational games, there are two different types of fantasy that describe the content of the game (Wilson, 2009). Endogenous fantasy is when the content and the fantasy are linked together. An example of this would be where a player is asked to count the number of plants that they are growing. In contrast, exogenous fantasy has no link between the fantasy and the content. An example of this would be solving an addition problem to move the racecar further along the track. They are fundamentally disconnected. There are tradeoffs between these two types of fantasy as well. While the exogenous fantasy is easier to devise because the designer does not need to connect the fantasy and the content, it does decrease the immersion that the player has. The endogenous fantasy is the opposite. The immersion is improved, but it is more difficult to come up with a fantasy that is connected to the content itself.

Chapter 3: Design

To assist in determining our theory on the effectiveness of gaming elements in learning situations, a proof of concept was developed. This proof of concept contained several problem sets which were developed to be tested by a group of middle school students. The problem sets were in a similar format to how a computer game would be played.

To begin designing a proof of concept to be tested by the students, a particular game element was chosen. We chose to test the effectiveness of teaching math within a fantasy story. Fantasy stories are very popular in today's culture, no longer relegated to the outcasts of society. Many fantasy storylines are found in mainstream media, such as movies, books, and, of course, video games. Teaching math through this common platform seemed to be a natural progression for making the material more relatable to students.

The next step, after determining what element was to be tested, was to find possible math topics, within the target skill level, which could be taught using this method. Not all middle school math topics are easily taught using fantasy storylines and for the design, there were a few reasonable options. We began with volume, surface area, probability, and algebra as possible topics to write into a fantasy story. Topics such as Pythagorean theorem were determined to be too difficult to explain in a game setting. Each topic was then paired with a possible fantasy story with which it could be taught and the topic with the most potential was chosen. The story chosen was surface area with the idea that houses, of varying shapes, were to be fireproofed so as to protect villagers from a dragon.

With a topic and storyline chosen, problem sets were developed to determine the effectiveness of teaching surface area through fantasy stories. The subject of surface area was split into increasing difficulties to have each section build upon what students were doing in the previous section; these

sections were labeled Villages, in keeping with the storyline. Each Village had a level of difficulty at which point, if a student were to receive a passing grade in a Village, the next Village's material would build off what was previously learned. Village 1 was a simple review section placed to remind students of their previously learned area and multiplication skills. Village 2 introduced the idea of surface area being the collective area of all the sides, yet the shapes were still only rectangular prisms. Village 2 started by giving students the equation with which to find surface area of a rectangular prism, yet did not explicitly state that the equation was for a rectangular prism. Village 3 went further into the idea of surface area by using an irregular shape, a square pyramid. Village 3 began with a couple warm up problems, asking for the area of the base and one wall and then built the pyramid using the information the students had just found. Village 4 combined the knowledge from the two previous Villages, yet tested the concept understanding by physically combining the shapes the students were already used to. By solving for a pyramid on top of a rectangular prism, the idea of surface area being the combination of the wall areas would be the ultimate proof of understanding, as students would no longer be able to rely on the rectangular prism equation. They had to fully understand what is part of the surface of the object in order to find the surface area of that object.

Once the smaller storylines were determined, a conceptual story for the entire project was created. The story for the villages was specific to the material being learned, so a general story was created to give meaning and motivation for the student's character. With each Village being a problem set, pictures and diagrams were added to the questions to ensure that students fully understood what each question was asking them to do. Each Village was developed in a way to introduce the skills first as a fantasy element and slowly introducing the real-life concepts.

Chapter 4: Methodology

The design was then to be tested by middle school students. To determine how much time was to be provided for each Village, the group play-tested the design. The group's times for each section were recorded and adjustments to the design were made. In order to provide for a reasonable length, questions were omitted and generous estimations were made.

To determine how interested students were in the design, a survey was created. The survey asked questions as to students' prior knowledge of the topic covered and their perceived abilities in math. These answers could then be used to find possible links between enjoyment of the game and math skill. The survey also asked how well students understood the concept after the game; this would then prove whether or not the design was suitable for teaching a concept. These multiple-choice questions were formatted with varying scales to ensure students answered questions truthfully. Some went from good to bad while others went from bad to good.

The survey also had open-ended questions to get more general feedback from students. These questions asked what the students liked, or did not like, about the game. This provided feedback as to what was done well and what could be improved upon, even if the students could not identify the specific aspect they would change. There was also a question asking what students would change about the game. This would provide feedback on things that could be changed for the future to please more students and reach a larger number of students.

The design was then given to a group of students to test. The students were split into small groups to facilitate data collection. Each group was given instructions and story at the beginning of each Village. Students were to solve the problem sets and write their answers on the provided paper

handout while a group member or advisor was to check answers before each student could progress to the next question. General times from the play-test were used as cut-off times for when to stop students from work on each Village to ensure data from all 4 Villages. When students finished a question, they were to raise their hand so their advising group member could check their answer, record the time finished or record the number of incorrect attempts at the question. Students were encouraged to ask questions, and the number of questions per problem was recorded along with incorrect attempts at completion. Once time was stopped for each Village the students were then given the next Village regardless of passing grade. Due to the nature of this test, it would be preferable to have information regarding having students re-do a Village, yet this was not a viable process given time constraints.

Once the students had completed the 4 Villages they were asked to answer the survey. Students were encouraged to be honest about their opinions as well as specific in their answers. Surveys were then collected, to be analyzed along with their Village handouts.

Chapter 5: Results and Discussion

In this chapter, results for our game are analyzed. The percent scores of the children in the separate class are shown for each Village tested. Class 1 was made up of students who struggle in math and Class 2 was advanced students. The scores represent the amount of kids who received each grade range in each Village. The surveys are also analyzed to see the opinions of the children who play-tested the game.

5.1 Game tests

We began our data collection by having children test out the game we had designed. Our game was broken up into four different Villages that were used to test children's knowledge of surface area. Two classes of middle-school children were given the game and allowed to play it. The only way to progress through each Village was to correctly answer the questions given. Students were not allowed to advance to the next problem until they finish their current problem. The following sections show the results of how children in each class scored in each game. Scores are broken down into: <65, 65-69, 70-79, 80-89, and 90-100, or what most schools consider the cutoffs for grades of an F, D, C, B, and A.

5.1.1 Village 1

The first village was used as a review of area. It was designed to be easy for children to get through and to make sure they knew how to calculate the area of rectangular shapes. It was the start of the storyline for the game and gave the students an introduction into why they are playing the game. The students were given two minutes to finish this village, and the scores they received are shown below in Figure 1.

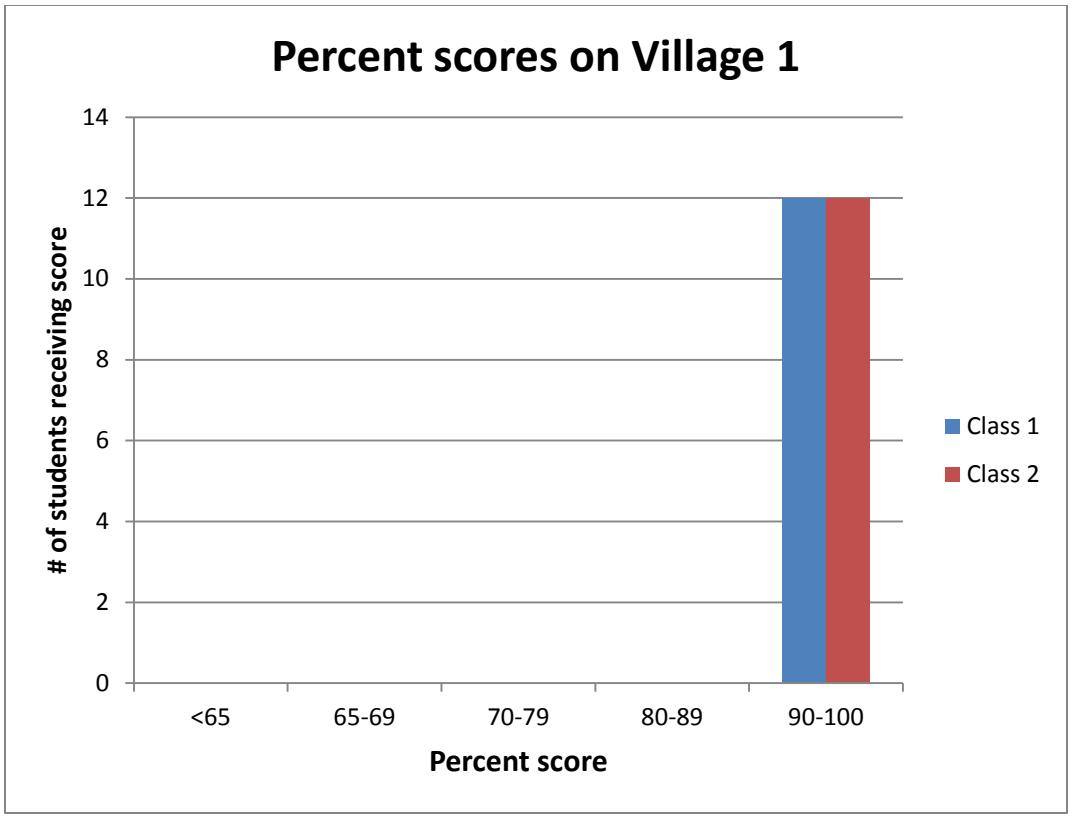

Figure 1: Breakdown of scores received by the students in each class in Village 1

The scores here show that every child was able to progress through the entire village and complete every problem with the time allowed. This shows that the problems here were simple enough for both classes to complete, which we expected to be the case when we created this village.

5.1.2 Village 2

The second village was where the surface area of a rectangular prism was introduced. The students were shown a hut with sides of a, b, and c and given the equation for surface area of a rectangular prism, which is:

$$SA = 2ab + 2bc + 2ac$$

The story progression was explained and students were given a time limit of four minutes to complete the village. Figure 2 shows the scores of Village 2.

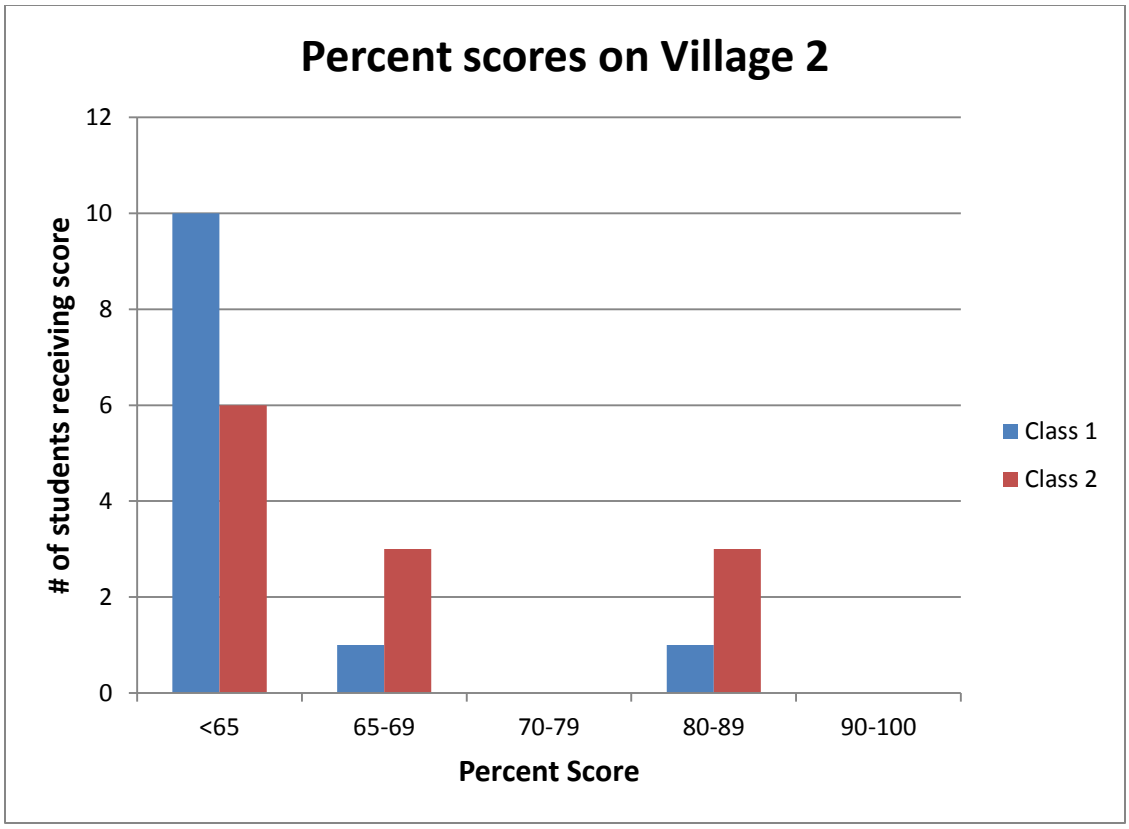

Figure 2: Breakdown of scores received by the students in each class in Village 2

The failure rate in this village was very high in both classes, with ten out of twelve students in Class 1 and six out of twelve students in Class 2 failing. For Class 1, of the students who failed, four of the students were not able to correctly answer the first problem. When asked about the Village later, they responded that they found it too difficult to use the equation without physically seeing a, b, and c next to their numerical equivalents on the hut. Class 2 also had issues with not having the letters next to the numbers in the first problem but the students were able to figure out the problem and pass on to the next question. Many students from both classes asked questions about the first problem and how the previous equation applied to the first problem. Some students at first thought they were supposed to solve for volume instead of surface area. To make the game more accessible to all students it would be best to place the letters in the picture for the first problem to help student visualize how the equation fits in the problems better and to emphasize that they are solving for surface area, not volume.

5.1.3 Village 3

Village 3 was another surface area problem set, but with pyramids as the huts instead of rectangular prisms. One big difference between the two shapes is that pyramids do not have a simple equation to solve for the surface area like rectangular prisms so this would help test that students understood exactly what surface area is. Square pyramids were used as the shape for the huts because they would be the easiest to find the surface area of when calculating the area of the square base and the four triangular walls since all the walls had the same area. Figure 3 displays the scores from Village 3 for both classes.

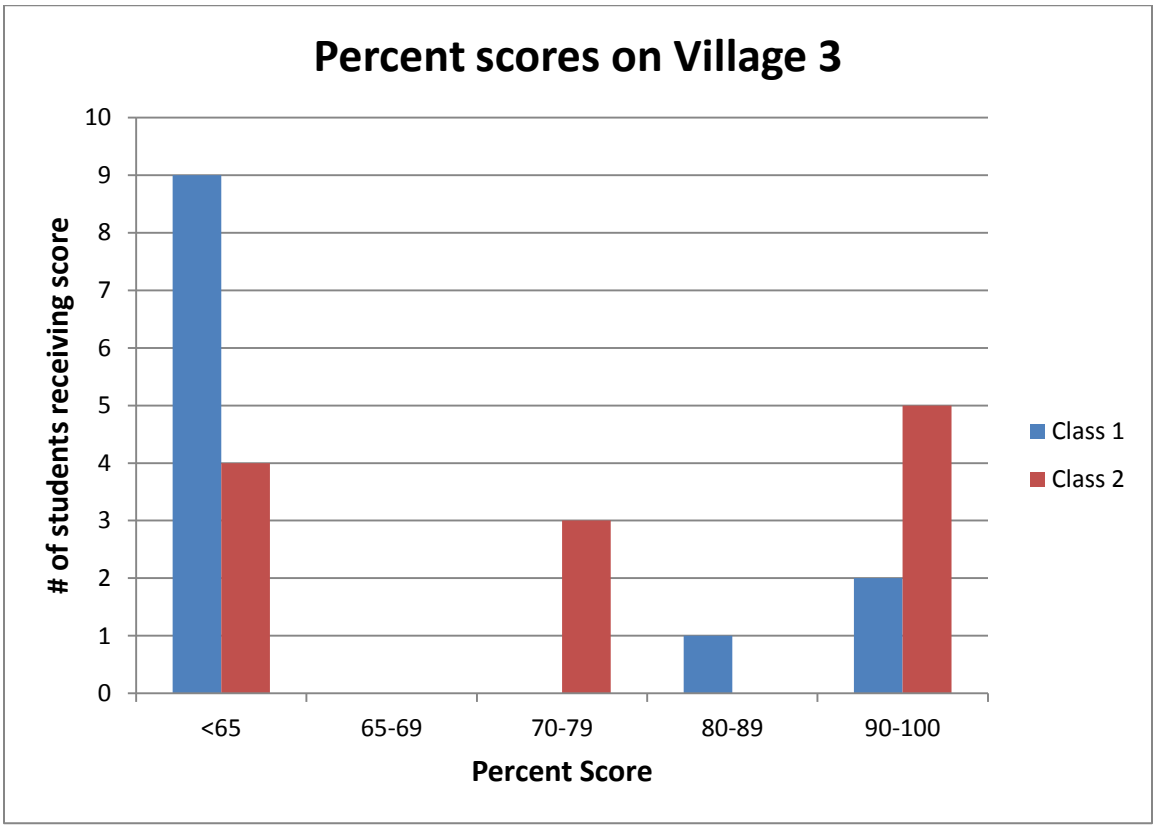

Figure 3: Breakdown of scores received by the students in each class in Village 3

This Village also had a high failure rate in Class 1, but two-thirds of the students in Class 2 were able to get past at least seventy percent of the problems. In this section, students were able to figure

out the surface area with a little more ease than in Village 2, but this may be due to the first several problems, which broke the house down into a floor and its walls in the first three problems and then combined them together in the fourth problem. This helped them see how the surface area for the shape came together and gave more students a better idea of what surface area actually is.

5.1.4 Village 4

The last Village combined the shapes from Villages 2 and 3 and made them into a new house that had a square prism as the base and a square pyramid as the roof. The surface area was equal to the combination of the two shapes minus the area of the top of the square prism and the base of the square pyramid. Figure 4 shows how students did in this Village.

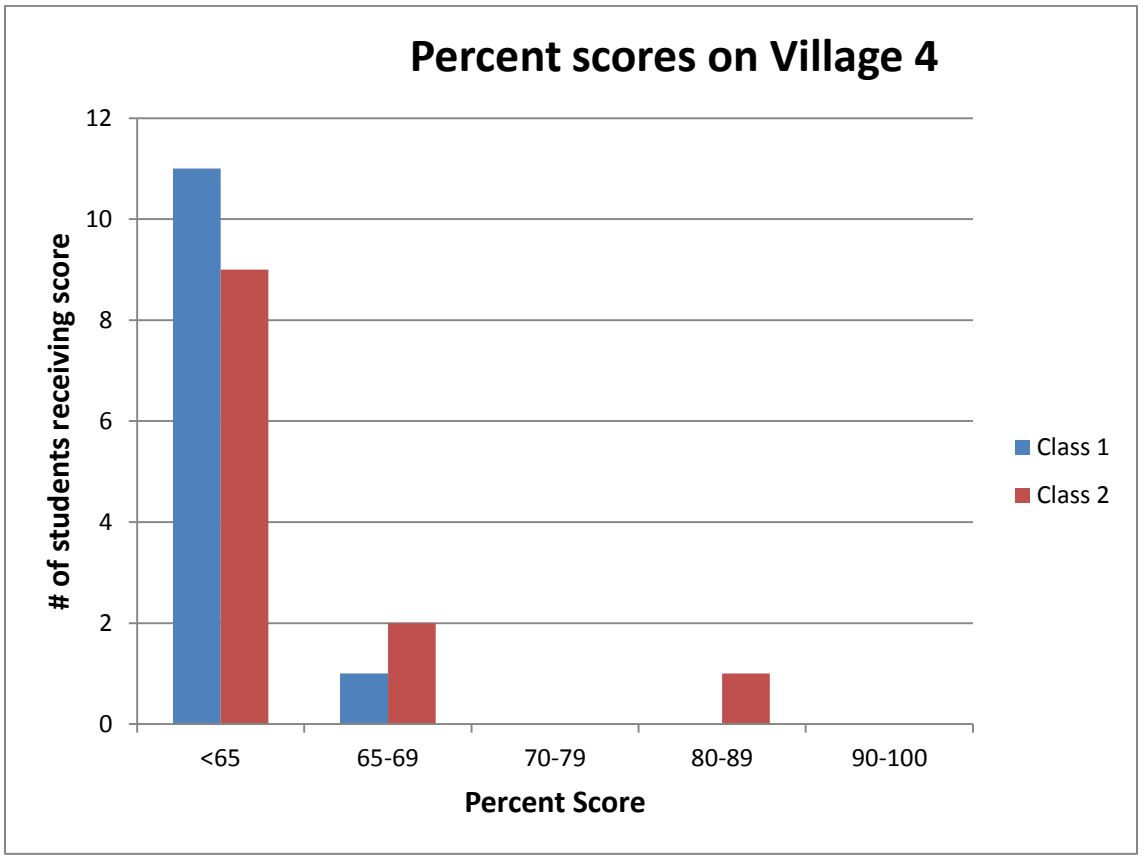

Figure 4: Breakdown of scores received by the students in each class in Village 4

Village 4 had the highest failure rate for both classes, with eleven of the twelve students in Class 1 and nine of the twelve students in Class 2 unable to get through at least sixty-five percent of the problems in the time given. Many students found it difficult to get through the third problem and were stuck there until the time ended. This occurred because many of the students in each class found it difficult to visualize removing the top of the square prism and base of the square pyramid to find the surface area of the new type of hut. They found it difficult to see this even with a three-dimensional view of the hut. It might help to put in another picture, or several problems, before the third problem so that the students can see that they need to get rid of the top of the square prism and the base of the square pyramid.

5.1.5 Overall game and survey

After the students completed each of the villages, they were asked to complete a survey we created, which is shown in Appendix C. The survey asked how well they understood the concept taught in the game before and after the game, how much they liked the game and how easy it was. There were also questions which asked what they liked and disliked specifically about the game and what they would change if they could

5.1.6 Class 1

This class' results showed that all of them enjoyed the storyline behind the game and found the combination of fantasy and reality to be interesting and fun. Many students came into the class not understanding surface area too well. Of those who came in with little-to-no understanding of surface area, almost all said that the game helped them to better understand it. This class generally disliked the math portion of the game due to their general dislike of math, but some students mentioned that they would like more time on the problems so that they could finish all of them. This class' overall results are shown in Figure 5.

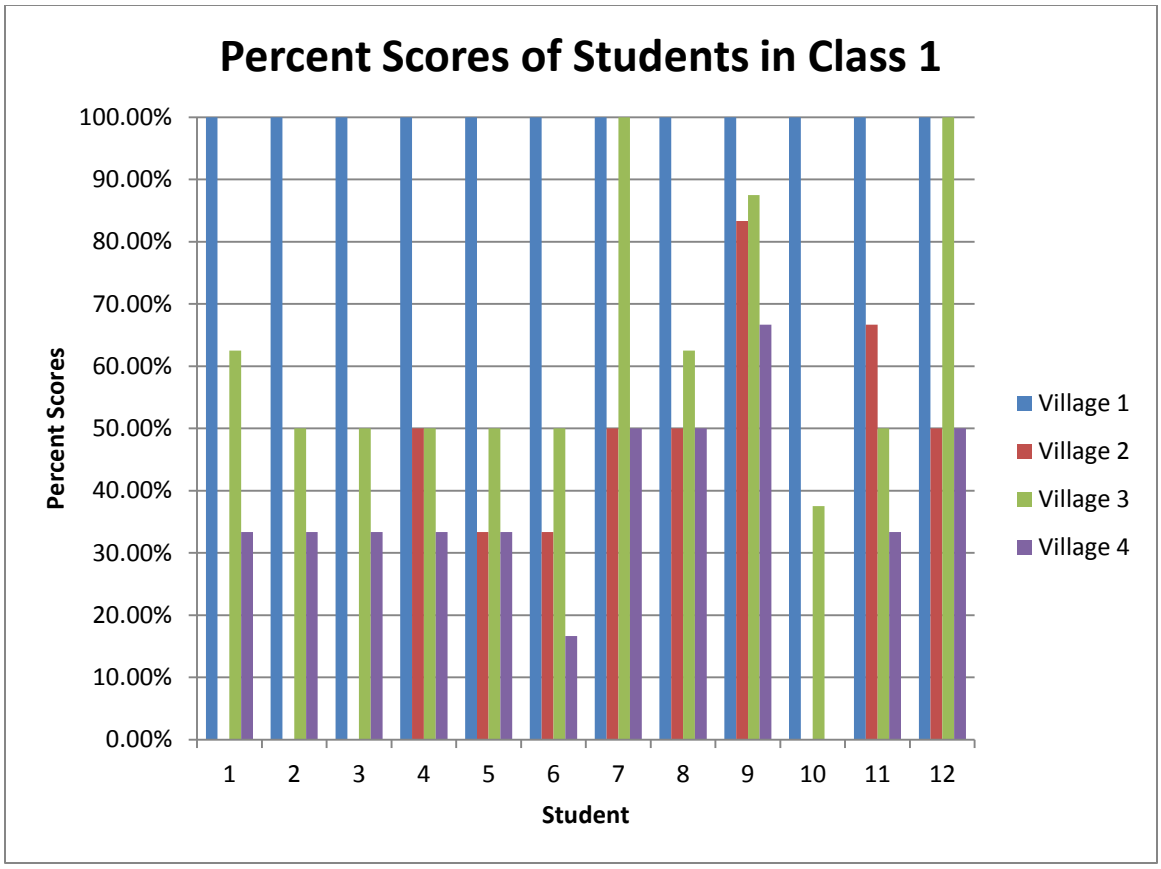

Figure 5: Scores received by each student in Class 1 in each Village

This shows that most students who did poorly in Village 2 were not able to get through half the problems in the rest of the Villages also. Increasing the time and adding in labeling for the sides could help increase students' scores.

5.1.7 Class 2

Results collected from Class 2 showed that the majority of the students liked the storyline and its combination with math. However, several female students disliked the storyline, and this could be because fewer females are typically exposed to fantasy elements in their childhood from items such as video games or books. This class also showed a general increase of comfort with the concept of surface area after they played the game. The scores for the students are shown in Figure 6.

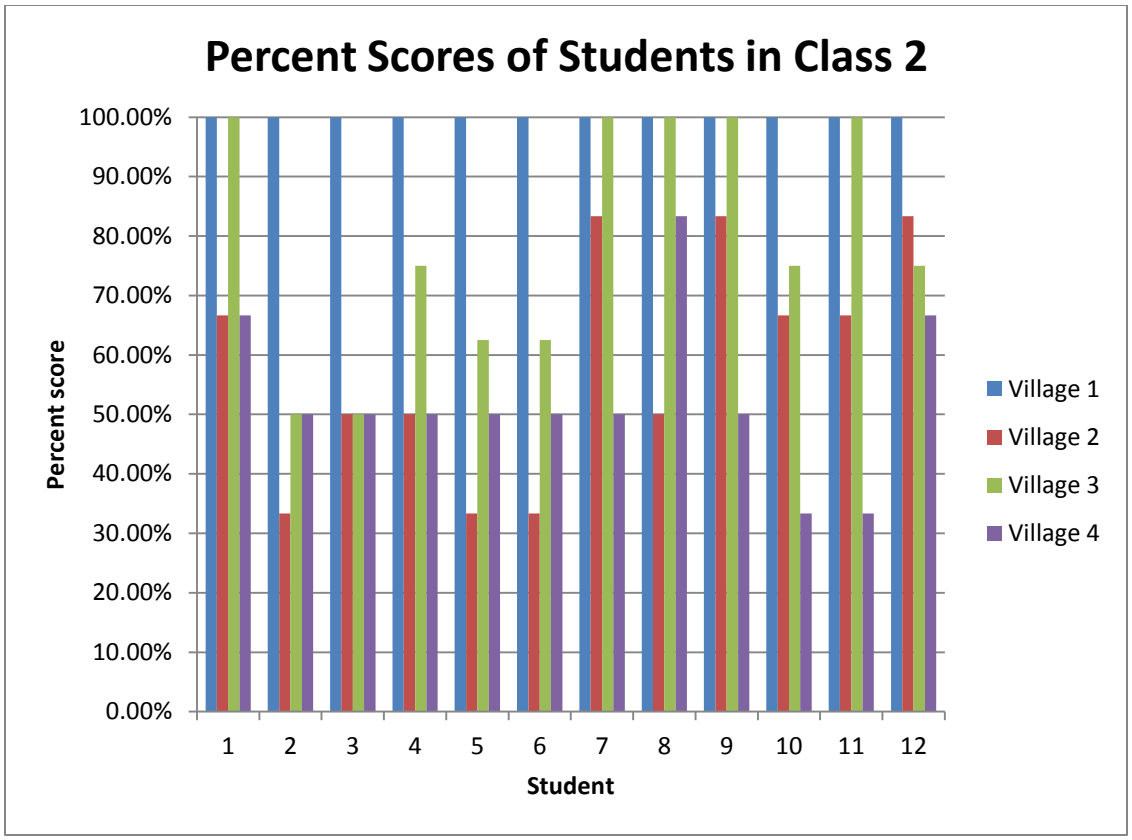

Figure 6: Scores received by each student in Class 2 in each Village

Trends in this graph show that those students who scored less than fifty percent in Village 2 were unable to get passing grades in the following Villages. Many of the students in this class also said that they disliked how much time was given for each Village, that they wanted more time to be able to finish all of the problems. Some thought that the problems were too difficult to answer because of wording or lack of equations, so the wording in some places should be simplified and more access to the equations in each Village would help the students get through the problems.

Chapter 6: Future Work

If we had had more time for this project, there would have been some changes made to the overall design of the game and how we tested it with the students. For the design of the game, we would have developed the storyline behind the game a lot further. The storyline was good enough for our purposes during testing, but could have gone more in depth on the reasons why the main character was trying to fire-proof the huts in each Village. We also would have created other storylines for different math concepts to teach the students, so as to have a better proof of concept for our design.

For testing purposes, it would have been better if we had more classes to test our game and have multiple classes in each level of math ability. That would provide a better cross-section that would show how the middle ninety percent of students would respond to our game and help further the design of the storyline and math problems in the game. When students failed Villages in our game-test, they were allowed to go on to the next Village even though they did not show full competency in the subject. We would like to be able to have students redo nodes that they did not pass so that they could fully grasp the concept taught in each node. This also would help further our proof of concept for our design.

Chapter 7: Conclusions & Recommendations

In this Interactive Qualifying Project (IQP) research project, we designed a fantasy-based game and analyzed students' scores and responses to the game. Overall, most of the students enjoyed the storyline for the game and found that the fantasy aspect of the game helped them to understand surface area more. Most of them said that the equations needed to be used more in the wording of the problems so that they can better see how the equations directly relate to the problems. There was a general consensus in each class, also, that Villages 2-4 needed more time so that they could be completed by more students.

This project does help prove our hypothesis that fantasy elements do help motivate and engage students in subjects they dislike. The students who disliked math in Class 1 did enjoy our game even though they did not the math portion of it, and they were able to get excited about the game they were playing. We recommend that different math subjects, with different supporting fantasy elements, be used in the game to see if this excitement about the game can be translated to other types of math and other fantasy elements. Time constraints should be increased in each Village so the students can have more time to get through the problems. We would also recommend that there be a way to send students back to the beginning of a node to retry it if they were unable to pass in the time allotted since we were unable to do this due to time constraints.

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Appendix A: Acronym List

IQP: Interactive Qualifying Project

Appendix B: Glossary

Node:	A section of our game in which there is a problem set for the students to solve, also known as a Village
Village:	See Node

Appendix C: Survey and Game

Survey:

Name:
Are you a boy or a girl?

1) How fun was the game compared to textbook problems?

Much Less Less Same More Much More

2) Did you know the formula for area of rectangle (length * width) before today?
Yes No

2b) Did you know the formula for surface area before today?
No Yes

2c) How well did you understand surface area before the game?

Did not understand at all
Sort of understood it
I could solve them but they're hard
I could solve those problems easily

3) How well do you understand surface area after the game?

I can solve those problems easily
I can solve them but they're hard
Sort of understand it
Do not understand at all

4) How easy was this game?

Very easy Easy Moderate Hard Very hard

5) What did you like about the game?

6) What did you dislike about the game?

7) How hard is math class?

It’s very hard
It’s pretty hard
It’s pretty easy
It’s my best subject

8) If you could change anything about the game what would it be and why?

Game:

Conceptual Story

An evil wizard has burned down the magic school and captured all of your former teachers and the students. You are the student wizard working for the King, who has now assigned you with protecting the kingdom and rescuing the captive teachers and students. You must now travel across the kingdom in search of the captives and the evil wizard so you can defeat him. All you have is your trusty wand and some basic spells you learned in the magic school. Go forth and protect the land!

Village 1

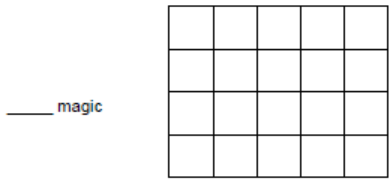
Name:

While traveling, you come to a village that is regularly being attacked by a dragon. While they do have some fire-proof enchantments on their huts, the enchantments are old and starting to wear off. The village people have asked you to re-apply some of the enchantments and you agree.

You only have to apply the enchantment to one wall at a time and you know that each unit of magic can fireproof 1 square stone

(timed and larger areas)
8 walls, 2 minutes

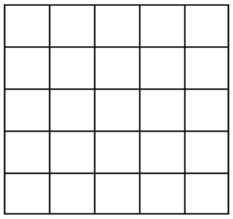
If a wall is 4 stone tall and 5 stones wide, how much magic do you need to fireproof it?



_____ magic

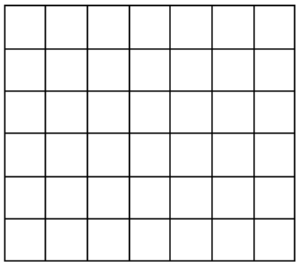
If a wall is 5 stone tall and 5 stones wide, how much magic do you need to fireproof it?

_____ magic



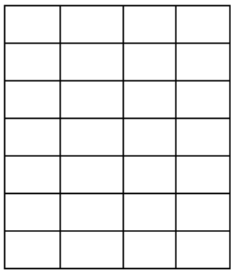
If a wall is 6 stone tall and 7 stones wide, how much magic do you need to fireproof it?

_____ magic



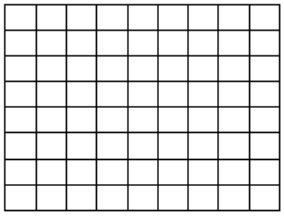
If a wall is 7 stone tall and 4 stones wide, how much magic do you need to fireproof it?

_____ magic



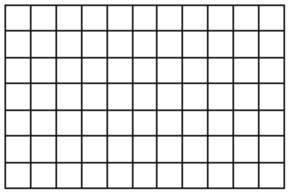
If a wall is 8 stone tall and 9 stones wide, how much magic do you need to fireproof it?

_____ magic



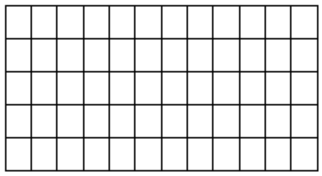
If a wall is 7 stone tall and 11 stones wide, how much magic do you need to fireproof it?

_____ magic



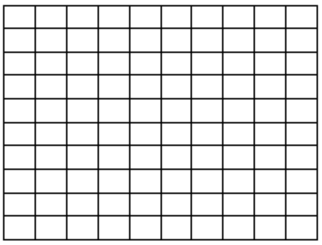
If a wall is 5 stone tall and 12 stones wide, how much magic do you need to fireproof it?

_____ magic



If a wall is 10 stone tall and 10 stones wide, how much magic do you need to fireproof it?

_____ magic



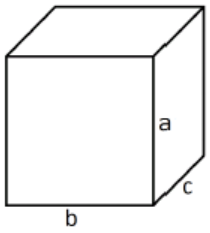
Village 2

The House as a Whole
6 huts, 4 minutes

Village 2

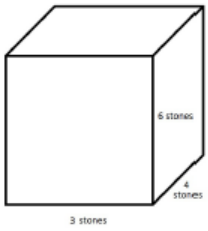
Name:

As you keep saving more houses and villagers, the dragon keeps getting angrier and angrier. You notice that the dragon is now flying to the villages faster so you need to find a quicker way to fireproof the houses. Looking through your spellbook, you discover an equation that determines the amount of magic needed to cover the huts that you've been fireproofing. This equation is: 2ab + 2bc + 2ac where a=the height of the hut, b= the width of one pair of walls and c=the width of the other pair of walls



Hut #1

How much magic is required to protect the next villager's hut, which is 6 stones tall, 4 stones wide on one pair of walls and 3 stones wide on another pair of walls?
(hint: Your spellbook includes a note that the amount of magic needed is the same as the surface area and SA=2ab + 2bc + 2ac)

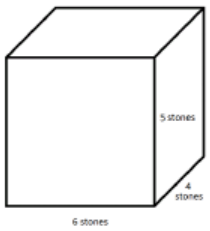


_____ magic

Hut #2

How much magic is required to protect the next villager's hut, which is 5 stones tall, 6 stones wide on one pair of walls and 4 stones wide on another pair of walls?

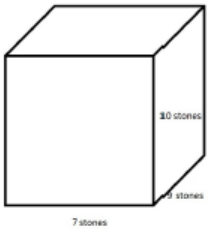
_____ magic



Hut #3

How much magic is required to protect the next villager's hut, which is 10 stones tall, 9 stones wide on one pair of walls and 7 stones wide on another pair of walls?

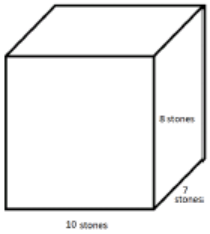
_____ magic



Hut #4

How much magic is required to protect the next villager's hut, which is 8 stones tall, 7 stones wide on one pair of walls and 10 stones wide on another pair of walls?

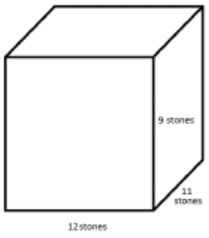
_____ magic



Hut #5

How much magic is required to protect the next villager's hut, which is 9 stones tall, 12 stones wide on one pair of walls and 11 stones wide on another pair of walls?

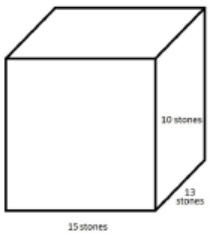
_____ magic



Hut #6

How much magic is required to protect the next villager's hut, which is 10 stones tall, 15 stones wide on one pair of walls and 13 stones wide on another pair of walls?

_____ magic



Village 3

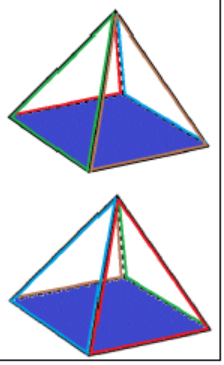
Changing the Shape of the house
(Regular Shapes)
6 huts, 6 minutes

Village 3

Name:

Pyramids

The next village you get to has huts shaped like square pyramids instead of rectangular prisms, so you can't use the spell equation from your spellbook on them. Luckily it's very far away from the last village so you have some more time to work before the dragon gets there.

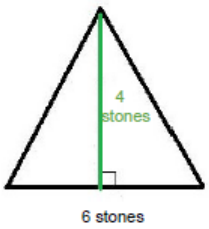


The floor of this house is 6 stones by 6 stones. How much magic is required to fireproof it?

_____ magic

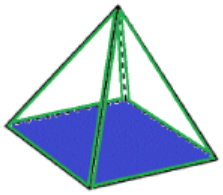
The wall of this hut is 6 stones wide and 4 stones high. How much magic do you need to fireproof it?

_____ magic



What is the total area of the four triangular walls?
(hint: each of the four triangle-shaped walls has the same area)

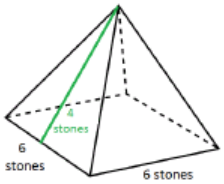
_____ magic



Hut #1

How much magic is required to fireproof this hut with a square floor of 6 stones by 6 stones (area of 36 stones) and walls with a base of 6 stones and a height of 4 stones (area of 12 stones each)?

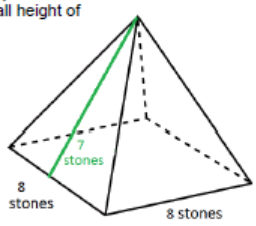
_____ magic



Hut #2

How much magic is required to fireproof a hut with a square floor of 8x8 stones and a wall height of 7 stones?

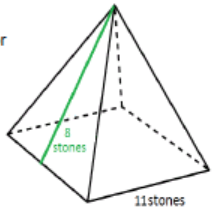
_____ magic



Hut #3

How much magic is required to fireproof a hut with a square floor that's 11 stones wide and a wall height of 8 stones?

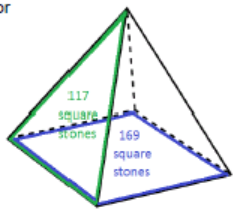
_____ magic



Hut #4

How much magic is required to fireproof a hut with a square floor of 169 square stones and one wall is 117 square stones?

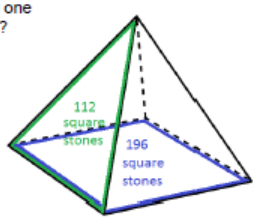
_____ magic



Hut #5

How much magic is required to fireproof a hut with a square floor of 196 square stones and one wall is 112 square stones?

_____ magic



Village 4

Pyramid-on-top-of-prism shaped huts

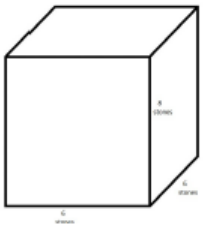
Village 4

Name:

In the last village, the huts are shaped differently than the other village's huts. The shape looks like a pyramid on top of a prism. You need to quickly fireproof the huts before the dragon arrives.

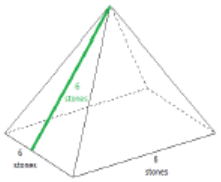
This hut's base is a rectangular prism with a height of 8 stones, a width of 6 stones on one side and a width of 6 stones on the other side. How much magic will it take to fireproof this part of the hut?

_____ magic



The top of the first hut is a square pyramid with a base of 6 stones by 6 stones and triangle height of 6 stones. How much magic will it take to protect this part of the hut?

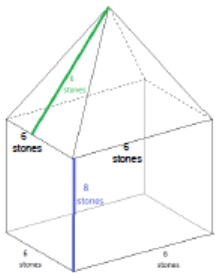
_____ magic



Hut #1

How much magic would it take to protect the whole hut?
(Hint: since the base of the pyramid and the top of the prism are within the hut, they don't count towards the surface area of the whole hut so don't include them)

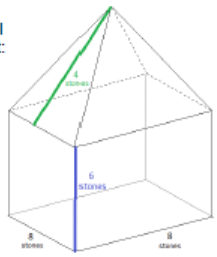
_____ magic



Hut #2

The next hut, shaped like the first hut, has a square base of 8 by 8, prism height of 6 and triangle height of 4. How much magic will it take to protect this house? (hint: base of the pyramid is the same as the base of the prism)

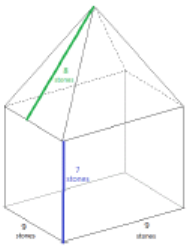
_____ magic



Hut #3

The next hut has a square base of 9 stones by 9 stones, a prism height of 7 stones and a triangle height of 8 stones.

_____ magic



Hut #4

The last hut has a square base of 100 square stones, a prism side area of 70 square stones and a pyramid triangle area of 45 square stones. How much magic will it take to protect this hut?

_____ magic