

Patterns in Literature

Rosemary G. Schmitt
Pittsburgh South Brook

Overview

Rationale

Objectives

Strategies

Classroom Activities

Annotated Bibliography/Resources

Annotated Reading List for Students

Appendices-Standards

Overview

It seems that in this country, there is a strong movement towards teaching our children to read. It's hard to believe that in 2009 we still have students coming out of our schools who can't read and parents struggling the same way. We focus so much of attention on reading and we find it embarrassing if we can't read. This to us is unacceptable. We as a society accept the fact that it's OK not to be able to do math. After all, as children, many of our adults couldn't do math either, and that's OK, or as it may be, "acceptable". This is why I gravitated towards finding math in literature.

With the shape of today's economy, our school district will be receiving stimulus money from the government to be used to improve the programs within our schools. This money has been ear marked for middle school literacy only. Our district will be instituting programs in our middle schools to help with this growing dilemma. Once again, everyone should be able to read. I strongly agree with this mind set. If our students can't read, then how do we expect them to perform in other classes? While teaching our students to be better readers, we can expose them to other content areas including math.

Many students struggle in math solely because they can't read or they simply don't understand what they are reading. This gets in the way of both teaching and learning. Stopping to understand the information is a big part of our lesson. It helps with student understanding and therefore enables them to perform the required math. They don't make that connection between being able to read and understanding the problem. As a result they struggle to do the math and consequently have a dislike for the subject, which again is socially acceptable.

We as teachers need to be flexible and look for other ways to incorporate the ability to read and the love for math. Rather than use our math book as a reading tool, why not look for fun stories and discuss the rich math embedded within? We as teachers need to change the way we look at math and literature so that no child is left behind.

I'm not looking to incorporate novels into my curriculum because our pacing would not allow for the time involved. But there are so many children's books that lend themselves to what is being taught in our curriculum, that by introducing some of these books, it would make the lesson both fun and meaningful. It would not be as time consuming and it would allow students to see the math concepts in a different way. Some of these books may also be familiar to the students and it would be fun for them to revisit them. There are so many books out there, but I would like to show how a couple would work when looking at patterns and algebra.

I currently teach 8th grade pre-algebra, and the books I am planning to use are for younger children, but you will see how a simple children's book lends itself to a pre-algebra classroom. As a result, this unit could be fun for any age and could help with algebra concepts at any grade level.

Rationale

Currently at Pittsburgh South Brook, we use CMP 2 (Connected Math Project). It is a discovery-based curriculum. It consists of interesting math problems embedded with mathematical concepts. The approach is to launch, explore, and summarize different mathematical concepts. As the students explore problems, they start to develop a deeper understanding of the mathematical concepts. The students apply skills that they have learned in previous lessons, as well as skills that were learned in previous years. It helps the students to recognize math as a way of thinking, making sense of situations rather than seeing math as a series of unrelated events. Because of the connection that is made between math concepts and problems, the students begin to enjoy problem solving. They see a connection between real life situations and math. They are usually familiar with the different types of life circumstances in the book and relating to them helps them to find ways of solving the problems.

Middle school students have a hard time developing algebraic thinking. In 8th grade pre-algebra, students spend most of their time looking for patterns and expressing those patterns symbolically. Most of my students really struggle. The students who do well in seventh grade, (those making A's in math), take Algebra I. The rest of them take pre-algebra (CMP 2). This again is problem centered and

the students solve the problems by eventually writing equations. We start with linear equations, follow through to exponential equations and end the year with quadratic equations. The students seem to have an easier time creating tables and graphs than they do writing a rule to fit the pattern. They are able to give verbal and written descriptions of the patterns, but find it difficult to express the patterns using symbols. We look at patterns using numbers in our tables and eventually write an equation to fit this pattern. Students have a hard time using symbols instead of numbers and relating this to what goes on in the real world. With the help of books and meaningful context our students will not look at mathematics as an irrelevant system. Activities that encourage students to investigate and extend patterns are essential in helping our students develop algebraic thinking. Literature creates an interesting environment for students to connect algebra to various situations.

I would like to go beyond what is in our connected math book and use children's literature to show and explain a number of different relationships. Lots of children's literature contains mathematical content that works well in a middle school class and fosters a much deeper exploration of mathematics. I think my students would find this both exciting and fascinating. Listening to a story may be the motivation needed for students to explore the patterns presented. It will help give them a new appreciation for children's literature and encourage the learning I had talked about earlier.

In the *Curriculum and Evaluation Standards for School Mathematics*, the National Council of Teachers of Mathematics (NCTM, 1989) suggests that our students become active constructors of mathematical knowledge, to be more than just problem solvers but problem posers. We need to provide these opportunities to all of our students. NCTM suggests that our students need to represent mathematical ideas in many different ways, through discussion, drawing, and most of all writing, not just numerically. NCTM views mathematics as a way of thinking that needs to be developed, not as just a series of rules to be mastered. It sees mathematics as a way for students to communicate for a variety of reasons in many different contexts. NCTM recognizes the use of children's books as a way of communicating mathematical ideas.

Through children's literature, mathematics can be seen as a common activity through different contexts. Through children's literature we can help students not just learn mathematics but love mathematics. Since many mathematical concepts are embedded in story situations, children's literature provides a meaningful context for the use of numbers, provides ample opportunities for problem solving, and help make it a personal experience. Children's literature uses and celebrates mathematics as a language.

The new “*Principles and Standards for School Mathematics*” set the same five goals as set forth in the 1989 Standards that all students should:

1. Learn to value mathematics
2. Become confident in their ability to do mathematics
3. Become mathematical problem solvers
4. ***Learn to communicate mathematics***
5. Learn to reason mathematically

We as teachers of mathematics need to communicate mathematically. By communicating mathematically we are promoting mathematics as a natural communication system. We can use mathematics to describe our world and experiences. By reading books that communicate mathematically our students see that this communication is not just for the math classroom but a way to interact with others on a daily basis.

We are probably most familiar with using children’s literature for problem solving, however mathematical stories can inspire students to change details in the story in different ways in order to pursue other dimensions of a problem. This helps them with the art of problem posing. The original story becomes the basis for many different outcomes. The more students have an opportunity to do this, the better their understanding of the mathematical concept originally developed. It also encourages students to write about mathematics, another important concept stressed in our 8th grade curriculum.

Children’s literature can be used to create reflective tasks and provides a source of problems at all grade levels. It can be used as a fun way to develop an understanding of operations. There are also many books that show wonderful ways of combining and separating large quantities. Students need more than simple story problems to use mental math computations. There are many great children’s books that give students an opportunity to compute large numbers. Some are fictional and some use real data. The context in children’s books provides a change of pace and can be a bit more fun and maybe even more realistic. By having students learn fractions through children’s books, they are able to explore ideas in an informal and open way. Children’s literature also helps bring new dimension to proportional reasoning. Many children’s books explore comparisons and proportional ideas through excellent stories.

My focus is on patterns, which are fascinating enough, but children’s literature provides a great source to explore patterns. Through children’s literature, our students see that mathematics can be developed out of our experiences. It can provide students with various experiences through history and culture.

Through all of the different ways we expose our children to math, I always hoped that “number sense” is a bi-product of all of their learning. I think it is one of the most important tools to possess in order to be successful in daily living. It is the ability to produce reasonable estimates, it helps in choosing the correct calculating procedure, and it helps in understanding the relative magnitude of numbers. It’s more than just a feel for numbers. There are many exciting stories that help develop this goal.

Beyond the rich mathematics children’s literature provides, there are also a lot of games and puzzles that can help provide a variety of math skills. Both games and puzzles provide the opportunity to use various problem-solving strategies: working backwards, looking for a pattern, simplifying a problem, or just by guessing and checking. Puzzles help students to become more confident in their math thinking and reasoning. Because of the time involved to figure out a lot of puzzles and games, students start to develop patience and the persistence to completely work through them. Both puzzles and games help students develop a risk-taking attitude which is important to their development. Students focus on a process, look for fairness, and start thinking about how their opponent may be able to win.

I hope to expose my students to a number of different children’s books that show patterns and a connection between those patterns and algebraic functions. Starting with linear equations, students will look at a number of different books and poems that display linear relationships. We will look at patterns by organizing our information in a table. Through showing calculations and generalizing the relationship students will be able to write a rule to represent the relationship. The major focus is to apply algebraic thinking rather than just finding an answer.

We will also discover linear relationships through a game the students can play. By working through the puzzle and recording their results in a table, the students will be able to both generalize a pattern and predict the outcome for future games. This will help students to look at games and the patterns they may follow. They can see that outcomes are not always random and predictions can be made.

Starting in the sixth grade, our students develop the ability to recognize, display, and reason about the shapes and visual patterns that are important in our world. We build on their elementary school exposure to shapes and begin analyzing the properties of these simple shapes. As eighth graders we don’t look at polygons except when using the Pythagorean Theorem or using an area model to multiply binomials. We don’t look at the relationship between the angle sum

and the number of sides. However, when taking the eighth grade PSSA exam, eighth graders are expected to find the angle sum of any polygon by using a formula provided on a formula sheet.

Through a particular children's book, I want to focus on polygons and on the side-angle relationship. Students will subdivide polygons into triangles using diagonals. By using the number of triangles, they can determine the sum of the angles for other polygons. Students will see that a square subdivides into two triangles, a pentagon into three triangles, and hexagons subdivide into four triangles. By triangulating different polygons, students will discover a rule to help them find the angle sum of any polygon. My goal is help student reason through this equation so it makes sense to them. This will help them to both retain and understand the equation when they need to use it on the PSSA exam. Students will create a table and show their calculations in order to come up with a rule.

Exponential relationships are also explored in our eighth grade curriculum. Through 2 different children's books students will continue to explore these relationships. Both stories take the students through a situation where ants and rice are compounded by doubling. After reading each of the books and through creating a table and working through the calculations, the students will generalize the relationship with a rule (equation). We will continue through this concept by going further to see what would happen if the ants and/or rice would triple instead of doubling. By comparing the tables and graphing both relationships, the students will see the magnitude of compounding. We will also change the direction of the story by having the ants and/or rice grow by a constant amount. The students will now create a different story and table their results. Now the students can review a linear relationship showing a constant rate of change. It is important for students to see the difference in a linear change and an exponential change. They can compare the tables of both relations noticing how much faster the exponential relationship grows in comparison to the linear relationship. They can also view this by graphing both relationships on the same set of axis, and by expressing the linear relationship using symbols, they can compare the equations and relate the beginning of both relationships in each equation and the growth factor.

Through the game "Sprouts", a topological game invented by two mathematicians at Cambridge University in England, students will discover a pattern by playing the game several times. The game is played by two people taking turns to draw a network. They start out with two points drawn on a piece of paper which serve as the original vertices of the network. By following a set of rules, the players take turns drawing edges. The last player to make a move wins. The students discover that no matter how many times they play, there is a certain

number of plays that can be made before a person wins. Then they can play the game starting with three points or vertices. Then play again with four points and then five points. A pattern will be observed and students will be able to make predictions about how long the game will last for a given number of points. After expressing their algebraic thinking verbally, they will try using symbols to express the pattern they have discovered.

In the poem “Smart” by Shel Silverstein, the students can look at a situation where the numbers of coins increase along with their value decreasing, but not by a particular pattern or amount. They will explore the pattern and verbally express the situation; but they will not be able to write a rule to represent it. They can talk and write about the mathematics but also see that not all situations are represented by patterns. The students can then see if they can change the poem to represent a pattern in either a linear or exponential relationship.

Finally we will look at *Anno’s Magic Seeds* by Mitsumasa Anno. This particular Anno book is full of rich mathematical patterns. The story is about a young man, Jack, who is given two magic seeds by a wizard. Jack is instructed to eat one seed and bury the other. He is told that he will produce two more magic seeds the next year and will not be hungry for the entire year if he eats one. Jack does as the wizard told him for seven years and then decides to bury both seeds. When Jack buries two seeds, he gets four seeds, eats one and plants the rest. He continues to eat one and bury the rest until he meets Alice, now the process changes. After Jack marries Alice, they have a child and the pattern changes again. Eventually their plants are destroyed by a storm, and fortunately they have preserved a few seeds which they plant and the patterns begin again.

Throughout this story, students will discover lots of interesting patterns and relationships. They will find patterns in the number of seeds produced each year. They will look at the number of seeds eaten as well as the number of seeds buried. This pattern can go on forever, but when Jack decides to bury both seeds, the pattern changes quickly. Again the students will look for patterns in the number of seeds produced, the number of seeds eaten and the number of seeds buried. The students will be able to verbally describe the pattern. They can easily display their data in a table and even graph the situation, but expressing the relationship symbolically is more difficult. As they continue their table, they can make predictions about how many seeds will be buried in a particular year, or when will they have to bury a certain number of seeds. This becomes challenging for them. There is so much more you could do at this point. Could Jack possibly bury that many seeds? By asking them approximately how long it would take to plant a seed, they can figure out how long it would take to plant the number of seed produced in a particular year. You can then have them figure out how many

seeds they could plant in a day, week, or year. As their numbers get bigger, you can use this opportunity to revisit scientific notation which lends itself to the 8th grade curriculum.

After Jack meets Alice the patterns and relationships become more complex. Students soon realize one variable depends on another. There are lots of different relationships going on with each pattern. Students need to use these relationships to justify their answers. The situation keeps changing within the story. This story may take some time, but the rich mathematics is well worth it. It is also interesting to have the students write their own ending to the story and have the class discover any new and interesting patterns that may arise. *Anno's Magic Seeds* is a simple children's book with so many middle school concepts.

Even though middle school students haven't studied algebra yet, our society has caused many of them to experience anxiety over the mention of it. Because of this it is hard for them to believe that they are able to explore algebraic relationships. By using literature as a way to explore patterns and express algebraic thinking, we can expose our students to a fun and interesting way to look at algebraic relationships. When students recognize and write about patterns they are developing their algebraic thinking. By using these stories, our students will find it easier to express relationships symbolically in algebra class. These activities will help them to better understand a more abstract approach to using symbols to represent real-world situations.

Objectives:

In this unit students will be able to recognize patterns in different situations and express the patterns both verbally and symbolically. I want students to be comfortable with algebraic rules and make an easy transition from the concrete to the abstract world. They will need to be able to make a table of their data and also show this representation in the form of a graph. They will read children's books, poems, and analyze games, to find and explore patterns. In some cases they will draw conclusions and write an equation to help them make predictions and better understand the situation. They will have an opportunity to change the end of a story or write their own to change the pattern in the story. They will also compare patterns of change and discuss how these patterns are the same and how these patterns are different.

Strategies

I want students to accomplish these objectives by reading children's literature which incorporates patterns. They will show these patterns by using tables, graphs, and writing equations. They will use these patterns to make predictions

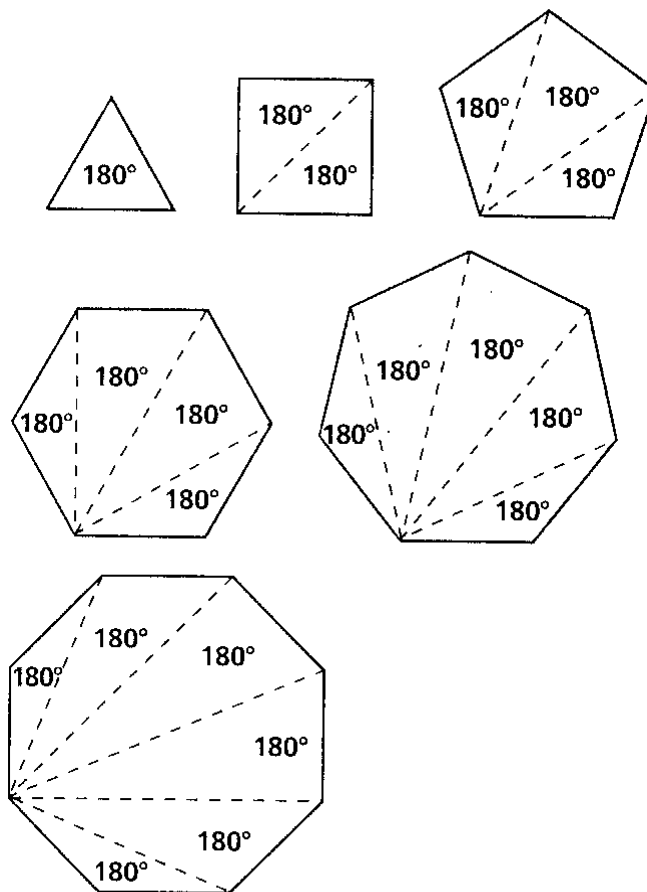
about particular situations. By talking and writing about their observations, they will start to show these relationships in an algebraic way.

Classroom Activities

Lesson One: “The Greedy Triangle”

The Greedy Triangle by Marilyn Burns is about a triangle that gets tired of being a triangle and is transformed into a quadrilateral by a shapeshifter. After spending time as a quadrilateral, he begins to feel dissatisfied and again the shapeshifter turns him into a pentagon. The story continues with the shape wanting another side again and again. The story shows a linear relationship which serves as a nice review after teaching *Thinking with Mathematical Models* in Connected Math.

After reading the story, the students construct a table showing the relationship between the number of sides and the sum of the degrees of the inside angles. At this grade level the students know that the total number of degrees in a triangle is 180° , so we start our discussion with the triangle in the story. This is where we will also start our table: 3 sides and 180° . From there we will add a side to our triangle, just like in the story, to create a square and show the angle sum of 360° . We can show this by having the students draw a square and drawing all the possible diagonals from that vertex. You have now triangulated the square into two triangles whose angle-sum is 360° ($180^\circ + 180^\circ = 360^\circ$). Every time you add a side to create a new shape, you draw diagonals from any vertex to all the other vertices to triangulate the shape. With each side that you add, you create another vertex and add one more triangle within the shape increasing the angle-sum by 180° . As the students create each shape and triangulate them, they record their results in a table showing eight sides. Have the students include another column in their table showing how they arrived at the angle-sum. The students can see that they need to add 180° with every new side. This will help them see the relationship between the number of sides and the angle-sum. The students can see that the number of triangles created within the polygon is 2 less than the number of sides of the polygon.



Next have the students predict the angle-sum of a shape that has 10 sides. After doing the required calculations, see if the students can generalize about the situation. From here see if they can use symbols to write a rule that would work with any number of sides.

Number of sides	Angle-sum	Mathematics
3	180°	180
4	360°	$2(180) = 360$
5	540°	$3(180) = 540$
6	720°	$4(180) = 720$

7	900°	$5(180) = 900$
8	1080°	$6(180) = 1080$
n		$n-2(180)$

Show that another way to write the equation is $180(n - 2)$. This illustrates the commutative property of multiplication. This is how the equation is showed on the formula sheet for the PSSA Exam.

Lesson Two: “512 Ants on Sullivan Street”

512 Ants on Sullivan Street by Carol A. Losi is a story about a family going on a picnic. As they continue on their way they pickup an ant carrying a crumb. Then they pick up two additional ants and then four additional ants, continuing to double until they have picked up 512 ants. The students can see the pattern is doubling with each additional encounter. By constructing a table, the students can try to find the relationship between the encounter and the number of additional ants. Have the students graph the relationship and they will soon see that this relationship is not linear. They can also see in the table that the number of ants is not changing at a constant rate but doubling. This is an example of exponential growth. The students explore exponential growth in Connected Math in the unit *Growing, Growing, Growing*. This story as well as the next provides the students with more opportunities to work with exponential relationships.

The table can start with encounter no.1 instead of “0”. To get the 2nd encounter, show 1×2 . As the students continue with the table and multiply 1 by a sting of 2’s, they will see that the power of 2 is 1 less than the encounter. This will help them to write a rule to represent the pattern.

Encounter	Number of Ants	Mathematics	
1	1	1	$1(2^0)$
2	2	$1(2) = 2$	$1(2^1)$
3	4	$1(2)(2) = 4$	$1(2^2)$

4	8	$1(2)(2)(2) = 8$	$1(2^3)$
5	16	$1(2)(2)(2)(2) = 16$	$1(2^4)$
n			$1(2^{n-1})$

After the students fill in the table for the first five encounters, have them take the table back to 0 encounters. This will be considered the beginning of the table. If they follow the pattern in the table, they will need to show that at zero encounters there would be half an ant. Explain that a half of an ant does make sense, but for writing the equation this will make it easier.

Now add two additional columns to show the mathematics involved and a simplified version. Start with .5 of an ant. To get 1 ant on the first encounter, double .5 or multiply .5 by 2. At the next encounter they take the “1” ant (.5 x 2) and multiply that by 2 again, showing $.5(2)(2) = 2$. To double 2 they continue to multiply the prior expression by 2 and continue to do so with each encounter. As the students continue to show the mathematics involved, they will see that the number of times they multiply by 2, can be simplified by using 2 to the power of the number of times they want to multiply it. They will see that the power of 2 matches the number of the encounter. When they go back to simplify the expression for encounter “0”, they can write 2^0 and use a calculator to show that 2^0 equals 1. This may be the first time they have seen that a number to the 0 power equals 1. They will also see that the variable is now the exponent resulting in an exponential relationship.

Encounter	Number of Ants	Mathematics	
0	.5	.5	$.5(2^0)$
1	1	$.5(2) = 1$	$.5(2^1)$
2	2	$.5(2)(2) = 2$	$.5(2^2)$
3	4	$.5(2)(2)(2) = 4$	$.5(2^3)$
4	8	$.5(2)(2)(2)(2) = 8$	$.5(2^4)$

5	16	$.5(2)(2)(2)(2)(2) = 16$	$.5(2^5)$
n			$.5(2^n)$

Lesson Three: "One Grain of Rice"

One Grain of Rice by Demi is a mathematical folktale about a raja that lived in India and believed he was wise and fair. Every year he kept all the people's rice for himself. When the famine came the people went hungry. A village girl does a good deed for the raja, and gets to choose her reward. She asks for just one grain of rice, doubled every day for 30 days. Through doubling, one grain of rice grows into more than one billion grains of rice.

This is another example of exponential growth. It will give the students another opportunity see the pattern and construct a table, resulting in writing an equation that can be used for any day in the 30 day cycle. Have the students construct the table using 1 grain of rice for the 1st. day and then another table starting with "0". Even though it doesn't make sense to have a half a grain of rice on day zero, they can see how it affects their equation. If they use their equation to find the number of grains of rice on day 30, they will need to write the number of grains of rice using scientific notation. This is another piece of eligible content on the PSSA exam and an opportunity to review scientific notation with your students. Again have them graph the relationship.

Day	Grains of Rice	Mathematics	
1	1	1	$1(2^0)$
2	2	$1(2) = 2$	$1(2^1)$
3	4	$1(2)(2) = 4$	$1(2^2)$
4	8	$1(2)(2)(2) = 8$	$1(2^3)$
5	16	$1(2)(2)(2)(2) = 16$	$1(2^4)$
n			$1(2^{n-1})$

Day	Grains of Rice	Mathematics	
0	.5	.5	$.5(2^0)$
1	1	$.5(2) = 1$	$.5(2^1)$
2	2	$.5(2)(2) = 2$	$.5(2^2)$
3	4	$.5(2)(2)(2) = 4$	$.5(2^3)$
4	8	$.5(2)(2)(2)(2) = 8$	$.5(2^4)$
5	16	$.5(2)(2)(2)(2)(2) = 16$	$.5(2^5)$
n			$.5(2^n)$

Take this story a little further by having the students have the grains of rice triple each day for 15 days and compare the out come. Have them graph the relationship on the same set of axis as the first relationship and compare the two.

Day	Grains of Rice	Mathematics	
1	1	1	$1(3^0)$
2	3	$1(3) = 3$	$1(3^1)$
3	9	$1(3)(3) = 9$	$1(3^2)$
4	27	$1(3)(3)(3) = 27$	$1(3^3)$
5	81	$1(3)(3)(3)(3) = 81$	$1(3^4)$
n			$1(3^{n-1})$

Another extension would be to increase the number of rice grains by adding 5 each day. Now the students will have another example of a linear relationship and all three can be compared.

Day	Grains of Rice	Mathematics	
1	1	1	1
2	6	$1 + 5 = 6$	$1 + 5(1)$
3	11	$1 + 5 + 5 = 11$	$1 + 5(2)$
4	16	$1 + 5 + 5 + 5 = 16$	$1 + 5(3)$
5	21	$1 + 5 + 5 + 5 + 5 = 21$	$1 + 5(4)$
n			$1 + 5(n - 1)$

By starting with 1 grain of rice on day one, the pattern shows that the number of times you add 5 is one less than the day you are on.

Have the students construct a second table taking the days back to “0” showing the y -intercept. Even though it doesn’t make sense in the context of the problem, the students can go from concrete to the abstract by representing the relationship in the form of $y = mx + b$. By following the same pattern of adding 5 each day, you would have to subtract 5 to get the equivalent amount of rice on day “0” which would be -4, ($1 - 5 = -4$). Instead of showing the mathematics involved, they can show the change from one day to the next which represents the “ m ” or slope of the relationship. Emphasize the y -intercept is when x or “the number of days” is 0 and is represented by the “ b ” in the equation.

Day	Grains of Rice	Change in grains
0	-4	5
1	1	5
2	6	5
3	11	5
4	16	5

5	21	5
n	$5n - 4$	

Again have the students graph the relationship. They can see how different the growth is in a linear relationship from the growth in an exponential relationship.

Lesson Four “Sprouts”

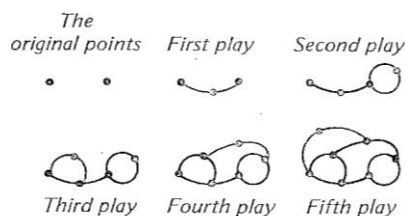
Two mathematicians at Cambridge University in England invented a topological game called Sprouts. Through this game, students can write an equation to make a prediction about the outcome of the game. It is a game where two people take turns drawing a network. It starts with two points or vertices marked on a piece of paper. Each player takes a turn connecting the dots by drawing edges to form a network.

- Each line or edge must connect two vertices or connect one vertex to itself.
- After the edge is drawn, a new vertex is placed on the line.
- No edge may cross another edge, itself, or pass through any vertex.
- There are to be no more than 3 degrees on any vertex.

The last person to make a play wins the game. Below is an example of how to play the game.

This game is over on play 5 because no more edges can be added

The students will play the game several times starting with 2 points or vertices, keeping track of how many plays it takes to win. Then the students will play using 3 dots or vertices (3 or 4 times) keeping track of how many plays it takes to win the game. The student will repeat the game with 4 vertices and then with 5, playing each level 3 or 4 times and still keeping track of the number of plays it takes to win. They will soon see a pattern of the number of plays it takes to win the game based on how many vertices they start with.



The students will then organize their data by creating a table showing the number of vertices for the game and the number of plays it takes to win. The students will try to figure out a rule that can be used to make predictions for any number of vertices. The pattern shows a constant rate in the plays needed to win the game based on every time a vertex is added. The students will express this linear relationship in the form of “ $y = mx + b$ ”. By using this form, students should be able to write a linear equation to fit the pattern. In creating the table, discussion should take place as to what the variables are and which one is dependent and independent.

Next have the students figure out the “ m ” or slope in the equation by showing the increase in plays for every increase in vertices. Now have the students take their table back to “0” in order to show the y -intercept or “ b ” in the equation, or based on this pattern, what the number of plays would be if there were no vertices. Even though this doesn’t make sense in the context of the problem, students need to understand that it is an important part of writing an equation to represent a linear relationship. With this information, the students should be able to represent this relationship with the equation “ $p = 3v - 1$ ” (p representing the number of plays and v representing the number of vertices). By having the students use letters to represent the variables, they are able to show an understanding of how the number of plays (p) is dependent on the number of vertices (v).

Number of Vertices	Number of Plays	Increase in Plays
0	-1	
1	2	
2	5	3
3	8	3
4	11	3
5	14	3
v	$3v - 1$	

Lesson Five “Smart”

“Smart” is a poem by Shel Silverstein contained in his book *Where the Sidewalk Ends*. It starts out with a father giving his son a one dollar bill for being so smart. The son takes the one dollar bill and swaps it for 2 quarters. Then he swaps the 2 quarters for 3 dimes and continues to swap his coins increasing the number of coins by 1 and decreasing the value of the coins.

The students can look for patterns and through discussion will realize that the situation can not be represented by an equation. They can look at the change in the value of the coins as well as the change in the change. This is a nice way to have students start looking at the pattern of change within a change.

The students should still construct a table to organize their information and show the change in the value of the total coins as well as showing the change in the change in value.

Number of Coins	Value of the Coins in cents	Change in the value	Change within the change
1	100		
2	50	50	
3	30	20	30
4	20	10	10
5	5	5	5

Have the students try writing a poem that shows a pattern representing a linear relationship.

Lesson Six “Anno’s Magic Seeds”

Anno’s Magic Seeds by Mitsumasa Anno is a story about a young man, Jack, who is given two magic seeds by a wizard. Jack is instructed to eat one seed and bury the other. By doing this he produces two more magic seeds for the next year, one to eat and one to bury. Jack continues this for seven years and then decides to bury both seeds. When Jack buries two seeds, he gets four seeds, eats one and buries the rest. He continues to eat one and bury the rest until he meets Alice, now they both eat one seed and bury the rest of them. When Jack marries Alice, they give away 2 seed to their 5 guest, save 16 seeds; both eat one and then bury the rest. Things continue in the story and the number of seeds buried keeps changing.

In this activity, the students make tables keeping track of the number of seeds eaten, buried and produced. For the first 6 years, the numbers stay the same.

Year	Seeds Produced	Seeds Eaten	Seeds Buried
0	0	1	1
1	2	1	1
2	2	1	1
3	2	1	1
4	2	1	1
5	2	1	1
6	2	1	1

In the next 5 years things change. Jack doesn’t eat any seeds in year 7 and buries 2, then continues to eat one and bury the rest. The students will create another table for year 7, but start the pattern again with year 1.

Year	Seeds Produced	Seeds Eaten	Seeds Buried
0	0	0	2
1	4	1	3
2	6	1	5
3	10	1	9
4	18	1	17
5	34	1	33

Now patterns are developing. The students can now verbalize and write about the patterns they see. There are relationships between the year and seeds buried and the year and seeds produced. Have the students look at the change in the seeds produced and the change in the seeds buried. The students continue recording the seed information after Jack meets Alice. The students can continue to write about the new patterns they notice.

Year	Seeds Produced	Seeds Eaten	Seeds Given Away	Seeds Stored	Seeds Sold	Seeds Buried
6	66	2	-	-	-	64
7	128	2	10	16	-	100
8	200	2	-	34	44	120
9	240	3	-	51	66	120
10	10	3	180	-	-	7
11	14	3	-	-	-	11

Even though equations are not being written to represent the relationship, patterns can be discussed and verbalized. Students have an opportunity here to write about their math and possibly write a different ending of the story.

Annotated Bibliography/Resources

Austin, Richard. Thompson, Denisse. “*Exploring Algebraic Patterns*”, *Mathematics Teaching in the Middle School*, (February 1977) Pages 274-81, 1977 NCTM.

Bresser, Rusty. *Math and Literature*, 2004, Sausalito CA, Math Solutions Publications.

Jacobs, Harold R. *Mathematics A Human Endeavor*, 1994, New York, NY, W. H. Freeman and Company.

Lappan, Glenda., Fey, James T., Fitzgerald, William W., Friel, Susan N., Phillips, Elizabeth Difanis. *Connected Mathematics, Shapes and Design*, 2009, Michigan State University, Pearson Prentice Hall.

Poulos, John Allen. *Once Upon a Number*, New York, NY, 1998, Basic Books.

Whitin, David J, Wilde, Sandra. *Read Any Good Books Lately?*, Portsmouth, NH, 1992, Heinemann.

Williams, Jenifer M., Martinie, Sherri L. *Math and Literature*, 2004, Sausalito, CA, Math Solutions Publications.

Annotated Reading List for Students

Anno, Mitsumasa. *Anno’s Magic Seeds*.

Burns, Marilyn. *The Greedy Triangle*.

Demi. *One Grain of Rice*.

Losi, Carol A. *The 512 Ants on Sullivan Street*.

Silverstein, Shel. *Where the Sidewalk Ends*

Appendix-Content Standards

- M8.A.1.1.1 Represent numbers using scientific notation and/or exponential forms.
- M8.A.1.1.2 Find the square or cube of a whole number (single digit) and/or the square root of a perfect square (without a calculator) and explain the relationship between the two.
- M8.A.2.1.1 Simplify numeric expressions involving integers, using the order of operations.
- M8.B.2.1.1 Determine the total number of degrees in the interior angles of a polygon in 3 – 8 sided figures.
- M8.C.3.1.1 Plot, locate or identify ordered pairs on a coordinate plane.
- M8.D.1.1.1 Continue a numeric or algebraic pattern (pattern must show 3 repetitions-may include up to 2 operations, squares and square roots).
- M8.D.1.1.3 Determine the rule of a function (given elements in an input-output table, chart or list – limit to linear function).
- M8.D.2.1.1 Solve one- or two-step equations and inequalities (should not include absolute values-one variable only).
- M8.D.2.1.2 Use substitution to check the accuracy of a given value for an equation or inequality (simple inequalities with one variable).
- M8.D.2.1.3 Determine the value of an algebraic expression by simplifying and/or substituting a number for the variable.
- M8.D.4.1.1 Graph a linear function based on an x/y table (integers only).
- M8.E.4.1.2 Make predictions based on survey results or graphs.