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A Closer Look into Discipline Specific Literacy Strategies for Mathematics

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A Closer Look into Discipline Specific Literacy Strategies for Mathematics

By
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A Capstone project submitted to the Department of Education and Human Development of The College at Brockport, State University of New York in partial fulfillment of the requirements for the degree of Master of Science in Education

Abstract

This study then looks into specific researched based literacy practices to determine which strategies are known to work and help students read. The study then looks into research-based literacy specific practices to determine which strategies are known to work to help students read. Then, I take what I have previously learned regarding why students struggle to read mathematical text, and take the literacy strategies I found to further modify them into discipline specific literacy strategies. The purpose of this study is to provide professionals, including myself, a toolkit of mathematical literacy strategies to use to implement into everyday instruction, ultimately increasing students content knowledge.

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Chapter 1

Introduction

Growing up I had a passion for mathematics, which became the motivational factor for pursuing and obtaining my Bachelor's of Science degree in Mathematics and becoming a certified teacher. During my secondary school years, I never made the connection between my classes. I believed what I learned in one class would not be applicable in my other classes. When I was in high school, the Common Core Standards were being developed; these standards pressed the incorporation of literacy into all of the content-area classrooms. Before beginning my Master's degree in Literacy Birth-12, I never viewed literacy as the content area teacher's responsibility to teach. I believed it was the job of the literacy instructor. I did however see the importance of literacy instruction at the adolescent level. Now that I am in my last semester of my degree program, my perspective has changed. I now appreciate the importance of incorporating literacy instruction into every classroom regardless of content. I also realize the value of implementing literacy strategies in a way that allows students receive help with reading text in addition to deepening their content knowledge. Without participating in the training to be a literacy specialist, I would not know how to incorporate literacy into the mathematics classroom. Similar to many teachers, my undergraduate experience never prepared me to teach literacy, which is why content area teachers are being resistant to incorporating literacy into content-area classrooms. These teachers lack the proper training and skills to teach literacy. Thus the reason I decided to become certified in Literacy. Additionally I chose to complete this Curriculum Design to provide mathematics teachers with a toolkit of literacy strategies to implement into their classrooms.

Problem Statement

The implementation of the Common Core standards reformed instruction in classrooms. The New York State Board of Education influenced the integration of literacy practices into the content-area classrooms. Many content area teachers are not trained to teach literacy, making the implementation of literacy more challenging. Teachers are intimidated by teaching literacy in the classroom along with feeling they are not responsible for teaching literacy. What teachers don't realize is students' do not arrive to the classroom with the knowledge of how to read disciplinary specific texts. The teachers are responsible for providing students with the essential tools to access content knowledge through reading. Today limited research is available on mathematic literacy strategies applicable at the adolescent level. Arthur Hyde is one researcher who wrote the book *Comprehending Math: Adapting Reading Strategies to Teach Mathematics, K-6* on this particular topic in 2006. His book only covered grades K-6. Other studies that were conducted did not specifically focus on mathematics.

Significance of the Problem

Content-area teachers have been encouraged to infuse disciplinary literacy skills into their instruction. Literacy, along with literacy instruction, are both essential in mathematics instruction (Draper, 2002). Literacy instructors lack the knowledge of the texts for the different content areas necessary for developing adequate theories that will support literacy demands of students in content area classrooms (Draper, Broomhead, Jensen, & Nokes, 2012). Content area teachers should collaborate with literacy instructors to develop the best possible discipline specific strategies students can use to advance their content knowledge. Since I am certified in Adolescent Mathematics, grades 7-12, and am currently in the process of being certified in

Literacy birth- 12, I could represent both the content area teacher and literacy instructor to create a strategy toolkit.

Purpose

The purpose of this research study is to provide myself, along with other professionals a toolkit to use in everyday instruction to improve adolescent students' literacy skills as well as help them build content knowledge. Current research is limited to literacy strategies to teach mathematics grades K-6. Little support exists for teachers who teach grades 7-12. Few suggestions are offered on how a teacher can assist their students in working through a mathematics text to build content-area knowledge (Draper, 2002). Secondary teachers' lack of support is just one example of how mathematics teachers are limited in the support they have to help students work through mathematical texts. Students need the assistance of their teacher to accomplish reading mathematical texts for content-area knowledge, but many teachers are not equipped with the knowledge and skills to do so. This curriculum design addresses the lack of research in the area of reading strategies to teach mathematics to grades 7-12. Since I do not have any human participants, I rely on the literature that I reviewed to further gain knowledge and insight into this area.

Research Questions

The research questions I have addressed throughout this curriculum design project are

1. Why do students struggle to read mathematics text?
2. What can teachers do to help students in accessing text?

3. What are literacy strategies that can be modified and used in mathematics instruction to aid students in gaining a deeper conceptual understanding of the content knowledge within the text?

Rationale

The objective of this study is to explore different literacy strategies and determine how these general literacy strategies can be turned into mathematics specific literacy strategies. Mathematics classrooms provide text-rich environments for students. Teachers must realize that they need to guide students through reading text (Draper, 2002). I reviewed literature to determine why students struggle to read, write, and comprehend the text in mathematics. I furthered my study by modifying the literacy strategies supported by research to ensure they will specifically help adolescent mathematics students; ultimately creating a strategy toolkit. In this capstone project I will present a range of literacy strategies that can be modified and used to help students access the language and literature provided in mathematics class. In the mathematics classroom, students are assumed to have the ability to not only decode words but also symbols and equations. These symbols and equations are forms of literature in a mathematics classroom.

Positionality

As the independent researcher of this Curriculum Design project, I am more than qualified to do this research. I currently possess a dual initial certification in Mathematics grades 7-12 along with the middle school extension to grades 5, 6. I am also certified in Special Education for grades 7-12. As I am presently completing my Master's of Science in Literacy Birth -12, this certification is pending and will be fulfilled in December 2015. The majority of the literature I selected for my research consists of studies that use a methodology resulting in

qualitative results. Qualitative studies are based on the interpretation of the researcher and how the researcher views and analyzes the data collected. Qualitative studies contain no numerical data to support the findings. The courses I have completed throughout my studies at The College of Brockport have exposed me to various qualitative studies, the majority of which present best practices and theories. This has prepared me to conduct my own qualitative study using literature to develop a strategy toolkit full of literacy strategies that can be used in the mathematics classroom.

Study Approach, Procedures, Methods of Data Collection

For this Capstone Project, I conducted a Curriculum Design. No human subjects were used for the curriculum project. Instead my data was collected through the literature (research articles) I gathered from The College at Brockport, State University of New York's online library system during my Spring 2015 semester. The databases I used consisted of Education Source and Academic Search Complete and EBSCO Search. The search terms used to find the research articles I chose are "mathematical literacy", "disciplinary literacy", "mathematical text", "literacy strategies", "teacher beliefs" and "disciplinary literacy", and "struggling readers" and "mathematics". The research collected furthered my understanding of why students struggle to read and write along with literacy strategies that can be implemented in the mathematics classroom. The results of the studies in the research articles are conveyed through a literature review. The information in the literature review assisted me in creating the Strategy Toolkit for the curriculum aspect of the curriculum design. The research articles I collected originated from various Journals such as the Journal of Adolescent and Adult Literacy, Journal of Educational Research, Reading Research & Instruction, Journal of Content Area Reading, Educational Studies in Mathematics, Journal of Reading Education, Reading Psychology, and The Clearing

House. Additionally, some research came from educational books on literacy. As I collected literature that gave me both reasons why students struggle and literacy strategies, I decided to organize the articles into an organizer that I created. The organizer contains the citation of the article and indicates whether the article provides reasons why students struggle or literacy strategies that can be used in the mathematics classroom.

Through a comparative analysis, I analyzed different pieces of literature regarding why students struggle to read math texts to what research based strategies can aid student in their struggles. Through this analysis, I was able to create a toolkit of literacy strategies that can be modified and used in a mathematics classroom. During the Fall 2015 semester I focused on creating the Strategy Toolkit using the data I gathered from the literature. I took the literacy strategies I found in the literature and analyzed them to determine how I can modify the strategies to meet the needs of students in deepening their content knowledge in mathematics. The purpose of this Curriculum Design is to provide myself along with other professionals a Strategy Toolkit we can use as a reference to implement strategies in the mathematics classroom.

Criteria for Trustworthiness

To ensure that the Curriculum design I conducted was trustworthy I followed three qualitative research practices. The procedures I followed are conformability, dependability, and transferability. Through these procedures I verified the validity of my qualitative research.

My qualitative research is valid through conformability because the data I collected is available for review such that my findings are obviously drawn from the data. The strategy toolkit I created was directly drawn from the literature I collected. Based on my research done on why students struggle to read mathematical text, I was able to choose the strategies for my

toolkit that would meet the needs of students. Additionally, all the literacy strategies I have chosen come directly from the research I have done on literacy strategies. It is clear that all of my findings directly come from the data/research that I collected.

The research that I conducted also follows the procedures of dependability. In the methods of data collection section I clearly identify where all of the research I collected came from. The literature I gathered consisted of research articles from the College at Brockport's online library search engines. The articles I collected mainly come from journals. Additionally, some of the research done on literacy strategies came from educational books on literacy. Over the course of two semesters I collected data, analyzed the data, and came to conclusions.

The last procedure that I used to ensure my research is valid is transferability. I provided much detail about my research; from this, other researchers are able to extend what I have done and complete a similar study. For example, a researcher can conduct a study very similar to this one but using actual human subjects to test the strategies. Additionally another researcher could conduct a similar study by expanding the research to include other content-areas besides mathematics.

Chapter 2: Review of Literature

The Common Core State Standards has enforced literacy instruction to be implemented into content-area classrooms. The standards are the reason disciplinary literacy has become so important at the adolescent level. According to Shanahan and Shanahan (2012), disciplinary literacy focuses on how an expert in a discipline uses literacy skills to comprehend a text in that discipline. Knowing exactly what disciplinary literacy means is essential to understanding what literacy looks like in mathematics. In order to continue with my curriculum project to create a

strategy toolkit, I needed to first gain a further understanding of why students are struggling to read in the mathematics classroom along with literacy strategies that can be modified for use in mathematics. I began by researching literature on why students are struggling to read mathematics text. I then found several articles that provided insight as to why students struggle. Throughout my reading of the literature I found that one of the reasons students struggle to read mathematical text is because they were never taught how.

Teacher Beliefs and Practices

Before literacy instruction can be incorporated into the classroom, content-area teachers need to be aware and willing to do so. Content-area teachers become frustrated with the suggestion that they implement literacy instruction into their classrooms (Draper, Broomhead, Jensen, & Nokes, 2012). According to Draper et al., some research studies have led literacy educators to believe that content-area teachers are resistant to the ideas revolving around literacy instruction in their classrooms. I believe content-area teachers are rebelling against the notion of content-area literacy because they were never trained to teach literacy. Content-area teachers are proficient in their content-area; however, when it comes to understanding their role in teaching literacy and language teachers don't realize particular teaching skills and knowledge are required to do so (Gleeson, 2015). Many teachers are unsure of how to incorporate literacy into their instruction. Gleeson states teachers have mastered their content-area but this does not hold true for disciplinary literacy. Draper et al. presents a resolution to these problems such as having teacher preparation programs improve their practices for preparing content-area teachers. Additionally, literacy courses in colleges typically do not change a teacher's opinion about the role of literacy instruction in the classroom (Draper et al.).

The definition of text is another topic open for discussion around teachers' beliefs about literacy. Students need to be exposed to both print and non-print materials used to convey meaning in specific content-areas. By exposing students to different types of text students are able to engage in disciplinary literacy practices along with learning the content (Jewett, 2013). Many content-area teachers view literacy as reading and writing of print texts and when they do incorporate literacy into instruction teachers simply add reading stories and/or textbooks to the lesson (Draper et al., 2012). In the study completed by Draper et al. the researchers worked together to redefine text as anything that can be used to represent, specify, or negotiate meaning. Text is not simply written in the form of printed words, it is much more broad. Rojano, Filloy, & Puig (2014) broadened their definition of text to any set of signs or symbols a person can make sense of. For example, as a certified content-area teacher of mathematics, I understand the literacies involved in reading mathematical text include reading graphs, diagrams, equations, and inequalities. An example of this in mathematics is problem solving which includes the use of numbers and symbols instead of print text (Jewett). Reading to gain content knowledge does not have to be completed through the use of print text. Mathematics teachers need to teach their students the different ways to engage with symbolic meaning-making (Jewett). If teachers redefine their definition of text they will better understand how to incorporate literacy into their classrooms.

Complexity of Word Problems

Besides the fact that students were never taught how to read mathematical texts nor were their teachers prepared to do so, students also struggle to read because the mathematical texts in their textbooks and other assigned readings can be complex.

Word problems are considered to be mathematical text. Students need to be able to read word problems for meaning. Mathematical text contains specific words and phrases that may require clarity before students are able to rewrite text into mathematical symbols when solving problems and equations (Hawkins, 2014). According to the definition of text developed by Draper et al. (2012), word problems would be considered text since it is something that a person could negotiate meaning from. Students need specific skills to be able to decipher a word problem, however not all students enter the classroom prepared with these skills. In the past, word problems have caused students anxiety, doubt, and forced them to guess in regards to the where parentheses, equal signs, and other mathematical symbols should be placed when solving the problem (Hawkins).

It is essential for teachers to educate students on how to read word problems. What exactly does it take to read a word problem and gain meaning from it? According to Yan Ping Xin (2007) from Purdue University a successful problem solver has the ability to correctly identify the mathematical structure of the word problem. This is similar to what students do when reading print text. Students need to understand the structure of what they are reading before they can comprehend the text. Xin also describes successful problem solvers as having the ability to take the structure of the word problem and store it in their memory for a long time so when they encounter a similar problem they will remember the structure and can successfully work on pulling out meaning. The last skill successful problem solvers obtain is the ability to decide what information in the word problem is relevant and which is irrelevant (Xin). Essentially successful problem solvers have problem schemata, which helps guide them through finding the important information or the problem (Xin). There are other important aspects of word problems students need to learn to be successful.

Many students experience difficulty with word problems because the problems consist of indirect language involving the use of key words that do not symbolize the operation the word typically represents (Xin, 2007). The word “times” is an example of this. When students see a word problem that contains the word “times” they automatically believe they should multiply; however in some cases the cue word does not represent the correct operation that should be done (Xin). According to Xin researchers have found students struggle more with word problems containing inconsistent language rather than ones containing a significant amount of information. Students have a preference when it comes to the type of story construction. Students also have a schema that only allows these specific story structures (Xin). Word problems are daunting for all of the reasons mentioned, causing students to often skip these problems or leave them unsolved on an assessment (Hawkins, 2014). Attending to these type of word problems require students to obtain the skills necessary. Teachers become responsible to teach students how to complete the word problems. If students do not learn how to persevere through these problems, they will not gain content knowledge and become frustrated because they will think the problem is too challenging. According to Xin when students encounter difficult word problems they need to take the information presented to them and reorganize it. Besides word problems, students struggle to read through the complex texts in math textbooks.

Complexity of Text

The way teachers and students use strategies is greatly influenced by mathematical texts (Massey & Riley, 2013). As students enter their adolescent school years, Massey and Riley state that students are required to read mathematic textbooks containing very different language patterns than the narrative patterns they were exposed to in elementary school. As students move up in mathematics classes, not only does the difficulty of the content increase but the text

become more abstract and complex as well (Shaw, 2007). The textbooks used in mathematics classrooms contain a plethora of academic vocabulary words along with words that have multiple meanings (Massey & Riley). Another feature of mathematic textbooks that make comprehension so difficult is the use of both natural and symbolic language (Massey & Riley). Students have difficulty recognizing these features of a text and are not equipped with the right tools or skills to begin deciphering. Mathematics symbols and expressions often relate to previous texts, requiring students to develop intertextual references to make meaning. Often in math instruction the material students are learning and reading relates back to the student's prior knowledge and linguistic experiences in mathematics (Rojano, et al., 2014).

Mathematics textbooks, especially algebraic ones, contain three different types of sentences. The first is the print sentence that contains only words, the second is sentences that contain both words and symbols, and the third type of sentence seen in mathematics textbooks are sentences containing only symbols (Massey & Riley). Examples of a sentence with only symbols would be equations, expressions, or inequalities. The way each one of these sentences is read is different. For the sentence containing only symbols, a student is not supposed to read the equation or expression from left to right like with print sentences (Massey & Riley). For example if $3(4x + 5y)$ was in their textbook, Massey and Riley point out that the order in which this is read and solved matters and determines whether or not the student achieve the correct answer. Understanding how to read the text is essential to comprehension. The ultimate goal of any mathematics teacher is for their students to have a deep conceptual understanding of the content. To further gain insight as to why mathematic textbooks are so difficult for students to read, I continued to review some more literature.

Research provides valid information on the difficulty of textbooks and content area literacy instruction. Students gain a deeper conceptual understanding of content when engaged in literacy instruction. Each content area has its own literacy demands that need to be met in order to engage students in such instruction (Johnson, Watson, Delahunty, McSwiggen, & Smith, 2011). Students can gain a deeper conceptual understanding of the content they are reading if they are equipped with the necessary skills. Becoming a strategic reader is essential for students to keep up with the complexity of text year to year. To become a strategic reader, teachers need to scaffold using instructional strategies that will aid in students ability to read the disciplinary text at that level (Shaw, 2007). According to Johnson et al., students gain deeper understanding of disciplinary knowledge through reading, writing, and thinking like experts in the discipline. Again, students do not enter the classroom with the skills to do this. Teachers need to explicitly teach students how the various texts used in the discipline are both created and used (Johnson et al.).

When examining math texts and how to read them, several aspects need to be analyzed. Grammar is essential to take into consideration when exploring mathematical text. Students learning math need to learn the language along with the syntax and grammar of proofs. When looking at mathematical texts it should be noted that they are structured and sequential (Johnson et al., 2011). Students struggle with recognizing the structures of text and are not sure how to read them. Students also struggle with being able to tell the difference between an example and a proof in the textbooks (Johnson et al.). Knowing the structure of the text, the syntax, mechanics, and conventions are essential to comprehending and accessing the text. In ELA students are expected to do this; however, students were taught and prepped in these skills to be able to do

this independently. Math teachers need to do the same in their classes if they want their students to obtain the skills necessary to gain content knowledge from the text they are reading.

Collaboration between Content-area teachers and Literacy Specialists

Literacy educators do not have the knowledge of the various texts and literacies required for each content area; therefore they cannot adequately develop strategies or theories to help support learners in various content areas (Alvermann, Reinking, Cobb, Brice Heath, VanSledright, & Yore, 2004). This is why literacy instructors and content-area teachers need to collaborate with each other to come up with the best plan of attack to help students gain deeper content knowledge through reading mathematical texts. Draper et al. (2012) claims content-area teachers have the knowledge of the texts used and the literacies needed to learn the content in the discipline. Collaboration between both types of educators not only improves literacy instruction in the classrooms, but will also improve the pedagogy since the content-area teacher is an expert on both the content and the pedagogy (Draper et al.)

The most important aspect for both the content area teacher and literacy instructor to remember is that literacy instruction provided to students needs to be supportive of the disciplinary learning that must take place (Johnson et al., 2011). The literacy strategies suggested by literacy educators need to be adapted and modified through collaboration with the content area teacher so the strategy can successfully help students access the content. Examples of literacy strategies that do not help students in the math discipline that Johnson et al. provide is using a word wall and using key words to solve math problems in textbooks. The word walls will contain words that unless explicitly taught the meaning can be confused because some words used in mathematics have different meanings in other contexts than in the mathematics disciplines (Johnson et al.). The second example of using key words to solve mathematics

problems in textbooks is not a beneficial strategy to use because mathematics experts have discredited this practice (Johnson et al.). Looking at these two strategies, each one could have been successfully used in a different discipline; they were not the best strategies to use in mathematics. For this reason, the collaboration between the content area teacher and the literacy instructor is essential. The literacy instructor would be able to supply the literacy strategies and the content area teacher would be able to determine if the strategy is useful for the content and how to modify the strategy to ensure it provides positive learning outcomes. It is inevitable that literacy educators and content-area teachers will face challenges throughout their collaboration. According to Johnson et al. the challenge teachers face is trying to determine which strategies have merit and how to develop knowledge of the approach to text at the adolescent level.

To be able to determine literacy strategies to use in mathematics, one must have an understanding of the reading, writing, and thinking that takes place to access the content information. According to Johnson et al. (2011) the field of mathematics “includes pattern recognition/generalizing, representation of mathematical models numerically/symbolically/graphically, and the dominance of proof as its foundational knowledge base.” (pp. 103). Knowing this will support teachers in determining which strategies are best suited to help students think about the text in this manner. Students in mathematics are required to interpret the connections between mathematical symbols, which can be done with the help of language clarity. Language clarity in mathematics is where the teacher provides explicit explanations and examples of how to translate the symbols and various mathematical text into words. Mathematics teachers and reading teachers should have a conversation about language clarity to be able to successfully help students achieve comprehension of the text (Hawkins, 2014).

Being literate in the discipline of mathematics can be defined as having the ability to be conversant in the field of mathematics (Johnson et al. 2011). Educators strive for students to have the ability to discuss major findings in mathematics and be able to read research related to these findings, which according to Johnson et al. are both skills that make you literate in mathematics. Ideally students will also have the ability to think like experts in the field, which means teachers need to have knowledge of how experts think. Johnson et al. points out that mathematical literacy embodies both number and graph sense which includes being able to interpret graphs and make connections between numerical and graphic representations. The language of mathematics is also something that needs to be looked at closely.

Research Based Literacy Strategies:

Now having a better understanding of why students are struggling, I decided to gather strategies I was able to modify to help students not only work through mathematical texts, but also assist them in gaining a deeper conceptual understanding of the content. The strategies discussed are as follows: Frayer Model, Inner Voice Sheet, Annotations, Analytical Graphic Organizers, KWC, Triple-Entry Vocabulary Journal, Creating Representations, New, Knew, and Questions, Jigsaw, and Most Important Word.

Frayer Model and Verbal Visual Word Association. To begin my search for literacy strategies I started with the article by Anne E. Adams and Jerine Pegg. This article put the literacy strategies studied into three categories. The first category is Vocabulary. Adams and Pegg (2012) suggest the use of Frayer Models and Verbal Visual Word Association (VVWA) as beneficial strategies to aid students in learning vocabulary. Both of these activities are considered to be word categorization activities that aid students in understanding concepts (Adams & Pegg).

Looking at each of the strategies individually, it is noticeable that these two are similar. The Frayer Model requires students to describe in their own words the characteristics of a concept, give both examples and non-examples, and write a definition for the concept (Adams & Pegg). According to Adams and Pegg the Verbal Visual Word Association strategy asks students to write a definition of the concept in their own words, supply a visual representation of the concept, and describe a personal characteristic of the term.

Inner Voice Sheet. The inner voice sheet is a strategy students can use while they are reading. Tovani (2011) uses the inner voice sheet as a formative assessment. Students are expected to stop multiple times during their reading and jot down notes about their thoughts. The students also write down any strategies they used as they read. Additionally students write down where they stopped to jot down these notes so when they refer back to the notes later on, they are able to find where in the reading they were thinking that specific thought (Tovani).

Conversation Calendar. The conversation calendar is a tool created by Cris Tovani. This strategy allows the student and teacher to communicate back and forth with each other in a conversation manner (Tovani, 2011). Not only does the conversation calendar support the collection of data but it also allows the teacher to build a relationship with the students. At the beginning of the year the conversation calendar is used to learn about your students but as the year progresses the conversation calendars can be used to assess students' curricular understandings (Tovani). It is suggested by Tovani that teachers write an open-ended question on the calendars and ask students to respond. The question should be designed to provide insight into a student's mastery of a concept (Tovani). Teachers can then use this information to guide their instruction and determine what needs to be re-taught to the class.

Annotations. The strategy of annotations is used to help students track their thinking (Tovani, 2011). This strategy is done during the reading of text. As students read they make notes of their thoughts in the margins of the text or even on sticky notes. Besides helping students track their thinking, annotations can be used as an assessment tool that allows teachers to understand the way their students are thinking about the text (Tovani). From this teachers can understand what students are struggling with and which ones may provide new insights that could be shared with the class. The annotations should be what guide the teacher's instruction for the next lesson (Tovani). According to Tovani, when students are asked by their teachers to annotate as they read, they are being given a purpose for reading.

Analytical Graphic Organizers. Another strategy discussed by Sewell (2013) is Analytical Graphic Organizers. The benefit to using the Analytical Graphic Organizer is that it can be used before, during, and after reading. This strategy can also be used during class discussions and for taking lecture notes. The Analytical Graphic Organizer is a great strategy to help students organize their notes in a way that when they go back to refer to the notes they will easily be able to understand them. This strategy can also help students to access text by helping students organize the key concepts in the reading, making it less daunting. Another benefit of using this strategy is it can be used as either a formative assessment or summative assessment.

KWC. The KWC strategy is a modified version of the KWL chart. This strategy is specifically for mathematics problems. The KWC assist students in working through a problem; it guides their thinking and helps them break the problem into smaller parts. The K stands for: What do we know? The W stands for: What do we want to know? And the C stands for: What are the constraints or conditions? (Hyde, 2006). Using this chart, students can organize the

information given in the problem so they are better able to understand what is given and what they need to do with the information.

Triple-Entry Vocabulary Journal. The Triple-Entry Vocabulary Journal strategy entails students writing down the vocabulary word in one column. In the next column they write down the definition of the term and in the third column students can draw a picture, graph, or diagram to help them remember the words. This strategy is most useful when students are dealing with a large number of vocabulary words while they are engaging in learning through both text and images (Sewell, 2013).

Creating Representations. Creating representations is a way for students to view things in a different form. Hyde (2006) suggests that students represent the information they have in different forms such as graphs, equations, or even a table. This will help students to understand the mathematical text they are reading because they are able to see it in different forms. Some students may be able to read and interpret a graph better than an equation, which is why creating representations is beneficial for students.

New, Knew, and Question. This strategy is a “during reading” strategy. As students read they stop at appropriate places to write down notes on the information they just read. In one column they write down information they already know, in another column they write down the information that is new to them, and in the last column students jot down questions they have (Gambrell, 1980). This process allows for students to monitor their learning. Questioning is a strategy that strategic readers use, which is why the New, Knew Question strategy is beneficial for students (Gambrell, 1980).

Jigsaw. The Jigsaw strategy, from my experience, is where students are assigned a topic or concept that they are supposed to become experts on. After the students have learned their topic, they gather into small groups containing one person per topic. During the group meeting, students are responsible for teaching their peers everything there is to know about the topic they were assigned. This strategy encourages students to work strategically with the reading and work collaboratively with peers (Sewell, 2013). Since we know that mathematics texts can be very complex and abstract, it would be beneficial to implement a strategy that will make the readings less daunting. The Jigsaw strategy does just that. This strategy makes reading more manageable because students would only have to read a small section out of a textbook rather than a whole chapter on their own. Teachers can break up a chapter or text into smaller chunks so it is more manageable for the students. Every student will still receive the same information, they just won't have to read everything themselves to learn. Since the Jigsaw makes the reading less daunting students are more motivated to read and they will read more closely, making them able to access the content information within the text.

Most Important Word. Bleich (1975) created the Most Important Word strategy where students stop at appropriate places as they read and write down the most important word according to them or the author. After they are done reading they then share the word and why they believed it to be important. Strategic readers often pause during reading to reflect on what they read and determine what information is important (Bleich 1975). This strategy can be used in mathematics with word problems. Students often have a hard time identifying important information out of word problems because they are so complex (Xin, 2007).

Chapter 3: Strategy Toolkit

Now having completed the research necessary to understand why students struggle to read mathematics text and have gained knowledge of what literacy strategies are available to be potentially used in the mathematics classroom, I am able to create my strategy toolkit. This strategy toolkit is a resource that other professionals and myself can use in the mathematics classroom. For my strategy toolkit I have compiled a list of research-based strategies I feel can be modified to assist in meeting the needs of mathematics students. For each strategy added to my toolkit, I discuss the steps for implementing the strategy, the purpose of the strategy along with a visual of an example and a memory clue. The toolkit could be printed out and bound to keep as a book of literacy strategies that can be easily accessible for use during instruction. The purpose of creating this strategy toolkit is to provide mathematics teachers with a set of tools they can use to aid in their students understand of content. As found in the research stated earlier, often times students struggle in mathematics class because they do not possess the literacy skills necessary to read, write, and comprehend mathematical language. It is the teachers' responsibility to teach their students how to read, write and comprehend in the math classroom.

Please note that any of the strategies in the strategy toolkit can be modified to meet the needs of almost any mathematics content. Teachers should use these strategies as is or modify them depending on the mathematical content they are trying to teach. The examples I provide for each strategy is just one example of its use. Each strategy can be used for various topics in math and should not be limited to the way I used them.

Name: Jigsaw

Source:

Draper, R.J. (1997). Jigsaw: Because reading your math book shouldn't be a puzzle. *The Clearing House*, 71(1), 33-36.

What does it look like?

Memory Clue:



Steps:

1. Students get together in groups. Each student is assigned a subtopic related to a larger topic.
2. The students work individually to research their topic; taking notes in one of the sections provided on the worksheet. Students are to write any key concepts needed to understand the topic.
3. Once all the students have become “experts” on their topic they will regroup and take turns teaching their peers about their topic.
4. As students present their findings, the audience records their findings in one of the empty sections on the worksheet.

Purpose:

The Jigsaw strategy could be used to enhance an adolescent student’s content knowledge in mathematics. Each student would be responsible for becoming an expert of one subtopic. After researching their subtopic, the student acts as a teacher and teaches their content knowledge on the subtopic to their peers. This promotes students using academic language and summarizing what they learned about a topic because students are required to use academic vocabulary as they teach their topic. Additionally, students will summarize their findings by only providing the essential concepts that their peers need to know. Since mathematical text can be dense and complex (Shaw, 2007), teachers can use the Jigsaw strategy to break a text into smaller chunks so the text is not as daunting to the students.

Mathematics Specific Example

Alternate Interior

Alternate interior angles are congruent. These angles can be found in between the parallel lines and on opposite sides of the transversal.

Corresponding:

Corresponding angles are congruent. Two angles are corresponding if they are in the same spot at different intersections of the transversal and parallel lines.

Alternate Exterior

Alternate exterior angles are congruent. These angles can be found on the outside of the parallel lines and on either sides of the transversal.

Same Side Interior

Same side interior angles are supplementary (they add up to 180 degrees). These angles are in between the parallel lines and are on the same side of the transversal.

Materials:

- Jigsaw handout (formatted to fit the needs of the topic being learned)
- Resources available for research: computer, textbook, dictionary, and thesaurus
- Any materials students will need to teach this topic to their class/group

Other Examples in Math:

The Jigsaw strategy is versatile and can be used in various ways to help students have deeper conceptual understanding of the content. Since the Jigsaw strategy could be applied to help students meet the majority of the New York State Common Core Standards for Mathematics grades 7-12, I decided to look at the standards and provide some specific examples of how the strategy could be used at different grade levels. Some other examples of topics the Jigsaw can be used for in mathematics are:

- The Number System: NYS Standards- 7.NS.1, 7.NS.2: The Jigsaw strategy can be implemented by assigning each student a type of number (real, rational, irrational, whole, and natural numbers) and having the students become experts on their assigned topic. Then students get into groups and teach each other the key information on the topic. The Jigsaw strategy would result in student's completing the highest level of Bloom's taxonomy, which is creating and evaluating. The students would have to create the lesson/material they want to teach their peers and they have to analyze and evaluate the content.
- Functions: NYS Standards- 8.F.1, 8.F.2: The Jigsaw can be completed with the Functions unit in 8th grade mathematics. Each student could be assigned two different functions. The students are then responsible for determining if the functions they are given are indeed functions and then justify their reasoning for believing so. Additionally, the students could further their learning and compare the properties of each function and represent the function in different ways. After they complete the Jigsaw they would group up with other students and present their findings about the functions they were assigned.

Notes to Self:

The Jigsaw strategy would work great with the example I have shown, or even with different parts of a problem. I could also use the jigsaw to assign each student a different chapter or section of a chapter to do and they report back their findings to the class.

Source:

Draper, R.J. (1997). Jigsaw: Because reading your math book shouldn't be a puzzle. *The Clearing House*, 71(1), 33-36.

Strategy Name:

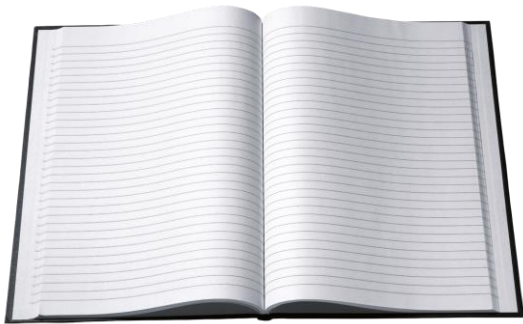
Triple Entry Vocabulary Journal

Source:

Vaughan, C.L. 1990. “Knitting Writing: The Double-Entry Journal” *In Coming to Know: Writing to Learn in the Intermediate Grades*, ed. N. Atwell.

What does it look like?

Memory Clue:



Steps:

1. Students are assigned a chapter or text to read.
2. As students read they write down any key vocabulary words in the left hand column.
3. In the corresponding box in the next column the student will write down the definition directly from the text.
4. Lastly the student rewrites the definition in his or her own words and/or draws a picture or graph to represent the word.

Purpose:

The Triple Entry Vocabulary Journal is beneficial in the math content area because it assists students in organizing and gathering their thoughts about the new vocabulary. Many mathematical texts, as stated earlier in the literature review, are heavy in complex words and academic vocabulary (Massey & Riley, 2013). This strategy can aid in making the reading more easily accessible so students can actually comprehend the content. Research also shows mathematical text contains a large amount of vocabulary words that contain multiple meanings (Massey & Riley). The Triple Entry Vocabulary Journal supports students in organizing their vocabulary words in one spot and deciphering the definition they find in the book for each word. Many of these definitions may sound complex or confusing to students, as a literacy specialist I believe having the students put the definition in their own word helps them remember the vocabulary because the definition is less daunting when it is written in a language they understand.

Mathematics Specific Example

Vocabulary Word	Definition from Text	Definition in your own words or a picture
Isosceles Triangle	“A triangle with exactly two congruent sides and two congruent base angles”	A triangle with two congruent sides such that the angles across from them are also congruent.
Equilateral Triangle	“All sides of the triangle are congruent” “All angles in an equilateral triangle are 60 degrees”	A triangle that has three congruent sides where all angles are congruent at 60 degrees.
Scalene Triangle	“A triangle with no congruent sides”	All sides of the triangle are of different measures.

Materials:

- Textbook
- Triple Entry Vocabulary Journal
- Dictionary
- Access to internet

Other Examples in Math:

The Triple Entry Vocabulary Journal is very useful in mathematics. Over the course of the year, students learn a plethora of vocabulary words in their mathematics class. All of the vocabulary words the students learn they will need to know in subsequent math courses. The Triple Entry Vocabulary Journal allows students to keep their vocabulary words organized and in one spot where they are accessible to them if the students need a refresher on what a word means. Below are some examples of mathematics topics from the New York State Common Core Standards of how the Triple Entry Vocabulary Journal can be used.

- The Number system: NYS Standards- 7.NS: The students can complete an entry into the Triple Entry Vocabulary Journal for each type of number they learn (real, rational, irrational, natural, and whole).
- Arithmetic with Polynomials & Rational Expressions: NYS Standards- A-APR.1, A-APR.2: The Triple Entry Vocabulary Journal can be used as a tool to help students initiate working towards meeting the standards listed. In order to be able to understand polynomials and what they do, students must first learn what polynomials actually are. The Remainder Theorem is another concept that students need to learn before they can apply the theorem to problems. Students could use the Triple Entry Vocabulary Journal to write down the definition of the academic vocabulary terms to deepen their understanding of what each term really means. Additionally, the Triple Entry Vocabulary Journal helps to meet the needs of different learners because the journal allows the students to use a picture, diagram, graph, or words and redefine or put in terms that they understand for each vocabulary word.
- Congruence: NYS Standard- G-CO.4: The Triple Entry Vocabulary Journal is beneficial because it guides students towards meeting some Common Core State Standards for Mathematics. The students can use the Triple Entry Vocabulary Journal to develop a definition for rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments. For each word the students could create their own definition. I believe the Triple Entry Vocabulary Journal would be best used after the students have seen each of these transformations modeled by the teacher and had a class discussion about what happens to the lines and angles after a figure is transformed by one of the transformations mentioned. This would allow students to use their discoveries to help them develop their own definition using the journal.

Notes to Self:

This strategy would be useful for students who struggle with organizational skills. All of their vocabulary words for a unit or module would be in one spot for them.

Source:

Vaughan, C.L. 1990. "Knitting Writing: The Double-Entry Journal" *In Coming to Know: Writing to Learn in the Intermediate Grades*, ed. N. Atwell.

Strategy Name: Frayer Model

Source:

Frayer, D., Frederick, W. C., and Klausmeier, H. J. (1969). *A Schema for Testing the Level of Cognitive Mastery*. Madison, WI: Wisconsin Center for Education Research.

<p>What does it look like?</p> <p>Memory Clue:</p> <p>Definition</p> <p style="text-align: center;">Characteristics</p> <p style="text-align: center;">Examples</p> <p style="text-align: center;">Non-examples</p>	<p>Steps:</p> <ol style="list-style-type: none"> 1. Students are provided the blank Frayer model (please see example below) at the beginning of class. 2. During the lesson or the reading of a text, the teacher stops at vocabulary words and asks the students to fill out the Frayer model for a specific word. 3. The students first write the definition of the word in their own words. Next, the students identify the characteristics of the word. Lastly the students write or draw examples, and non-examples of what the word could look or sound like.. 4. Students keep the Frayer Model in a binder to refer back as necessary to learn the word.
<p>Purpose:</p> <p>The Frayer Model is best used during the reading of a text and/or during note taking in class. The Frayer Model is a literacy strategy that assists students in understanding and learning the vocabulary words. The Frayer Model is a great tool for mathematics students to use because math itself is visual and the Frayer Model provides opportunities for students to draw pictures, graphs, and/or symbols of examples and non-examples. Hawkins (2014) states that students need clarification on words, symbols, and phrases before students can rewrite them in mathematical terms. By allowing students to focus on each vocabulary word independently, students gain a deeper conceptual understanding of what these key terms are and how they are used in mathematics.</p>	<p>Mathematics Specific Example</p> <p style="text-align: center;">Linear Function</p>

	<p>Definition: A function that graphs as a straight line and has variables with no exponents or powers.</p>	<p>Characteristic: A linear function either increases or decreases at a constant rate. On a graph, a linear function is a straight line; it must pass the vertical line test.</p>
	<p>Examples: Step functions $y = mx + b$</p>	<p>Non-examples: Quadratic functions $y = x^2 + 4x - 3$</p>

Materials:

- Blank copies of the Frayer Model
- Textbook or some other mathematical text
- Pictures/diagrams/graphs of the word being used

Other Examples in Math:

The Frayer Model is a diverse strategy that is applicable to various mathematics topics. Below are some examples of mathematics topics that align with the New York State Common Core Standards that the Frayer Model could be applied to:

- **Circles:** NYS Standard G-C.2: Students can use the Frayer Model to meet the Common Core Standard listed with the words inscribed angles, radii, and chords. By completing the Frayer Model for each of these words, students are able to identify and describe the relationships among the inscribed angles, radii, and chords with in their definitions and examples. The Frayer Model also can lead to the students completing standard G-C.3, which is constructing the inscribed and circumscribed circles of a triangle. The teacher could have the students use the examples and non-examples part of the Frayer Model to construct visuals of each.
- **Conditional Probability & the Rules of Probability:** NYS Standard S-CP.1, S-CP.3: Students could complete a Frayer Model for the vocabulary words of unions, intersections, and complements. When the students attempt to complete a task that is aligned with NYS Common Core standard S-CP.1, the students can refer to their completed Frayer Model of each word and use it to help them describe events as subsets of a sample space using the characteristics (unions, intersections, and complements).

Notes to Self:

The Frayer Model would best be used in a booklet format. Providing students a journal/book full of blank Frayer Models allows them to have the vocabulary words in one spot and to compare and contrast the vocabulary words that are similar. The Frayer Model would be very useful in Geometry since that course is very visual.

Source:

Frayer, D., Frederick, W. C., and Klausmeier, H. J. (1969). *A Schema for Testing the Level of Cognitive Mastery*. Madison, WI: Wisconsin Center for Education Research.

Strategy Name: Analytical Graphic Map

Source:

Ausubel, D. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart & Winston

What does it look like?

Memory Clue:



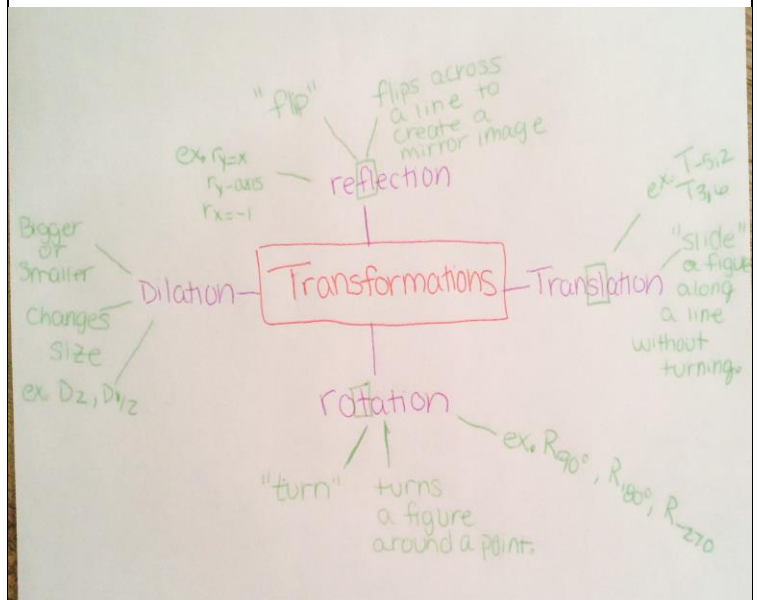
Steps:

1. Students begin by skimming through the assigned reading or graph.
2. Students will identify key ideas (most likely the subheadings of a text). The students should write down the key ideas on their blank pieces of paper.
3. As students read through each section of the text they will branch out from the key idea they identified by writing the ideas pertaining to each key idea they wrote down in a way that shows how the author organized their ideas.
4. Students then can look at each category and map the ideas so they can see the connections between the categories.

Purpose:

The Analytical Graphic Map would be beneficial in a mathematics classroom to help students build their content knowledge. As students read they will make a graphic map of how the author organized the information in the text or how they themselves connected the information in the text. Since mathematical text is dense and complex (Massey & Riley, 2013), having students create a graphic map will assist students in making connection within the text in various ways. The Analytical Graphic Map could assist students in becoming a more strategic reader, which is necessary since the complexity of text increases from year to year (Shaw, 2007). The Analytical Graphic Map allows students to see the relationships between mathematical concepts.

Mathematics Specific Example



Materials:

- Notes from class
- Scrap paper or premade cut up strips (made by teacher)
- Textbook

Other Examples in Math:

The graphic map can be applied to many different mathematical concepts. The number system is one example of how the graphic map can be implemented. The students could organize the types of numbers (real, irrational, rational, integers, whole, and natural) by the relation they have to one another. Below I have listed several other examples of ways the graphic map can be used to help students meet the New York State Common core Mathematics Standards.

- **Functions:** NYS Standards 8.F.1, 8.F.2: The Analytical Graphic Map could be used to help students organize the different functions they learn about. This requires students to analyze along with compare and contrast the functions to organize the functions in a way that makes sense to them. The Analytical Graphic Map requires students to complete a higher order thinking skill, analyzing, from Bloom's taxonomy. An example of the Analytical Graphic Map can be seen above in the picture under "Mathematics Specific Examples".
- **Complex Number System:** NYS Standard N-CN.1, N-CN.2: Teachers can have students analyze the complex number system through the graphic map. Students would use the complex number " i " and show the different values " i " can equal when raised to different powers. Another branch in the graphic map could be stating the form for complex numbers ($a + bi$) and giving examples. Anything there is to know about complex numbers may be added to the graphic map. The completion of the Analytical Graphic Map can be done in two ways, the first option is the teacher provides the students with cut up pieces of paper with different facts about complex numbers and the students work in small groups to organize all the pieces of paper in a manner that is accurate and makes sense. The second option is that students could use their notes on complex numbers to find key ideas and organize the ideas so the student can see how everything connects.

Notes to Self:

I believe the Analytical Graphic Map would work best in groups when learning a new concept or even to review older concepts so students can see the thought process of their peers.

Source:

Ausubel, D. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart & Winston.

Strategy Name: Inner Voice Sheet

Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publisher

What does it look like?

Memory Clue:



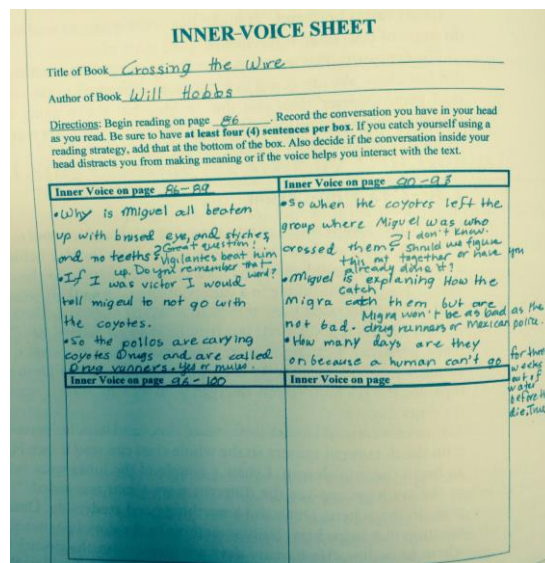
Steps:

1. Students are assigned a reading.
2. While reading the students will record their thoughts on the inner voice sheet. Students will write the page number and several sentences about what they were thinking.
3. If students use a reading or problem solving strategy they must make note of the strategy at the bottom of the respective box.
4. Lastly the students must decide whether the conversation they had in their head has distracted them or helped them make meaning of the text they are reading.

Purpose:

The purpose of the Inner Voice is to help students track their thinking as they read. The Inner Voice also helps students to monitor their own comprehension and recognize if their comprehension is still there or not. As students read mathematical text they may become distracted because the text is too complex and students become confused. With the inner voice sheet, students are required to stop reading and record their thoughts before continuing. This ensures that students don't continue reading while they are still thinking about something else. The Inner Voice Sheet provides students time to process the information and really let the content knowledge they are gaining set in. The Inner Voice Sheet also helps students to break down the text. Since mathematics texts are complex and dense (Massey & Riley, 2013), having students stop occasionally to write their thoughts or key concepts allows them to not become overwhelmed with information and reflect on their learning.

Mathematics Specific Example: Pg. 50



Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publishers

Materials:

- Textbook or some other mathematical text
- Notes from class
- Homework assignment

Other Examples in Math:

Students typically use the inner voice sheet created by Cris Tovani when they are reading, however I feel this strategy would best be used in math when it is used while students complete their homework assignments. Students can use the inner voice sheet to demonstrate their thought process as they complete their homework problems. The Inner Voice Sheet not only allows students to reflect on their learning but it also allows teachers to see where there are any confusions or misconceptions. Below are some examples of topics the Inner Voice Sheet can be implemented with that are aligned with the New York State Common Core Standards.

- **Ratios & Proportional Relationships:** NYS Standard 7.RP: Students could use the Inner Voice Sheet to write down their thought process for setting up a ratio or proportion as they work through various problems. Students could write down thoughts such as how they determined whether they needed a rate or a proportion. Additionally students could write down any common themes they are noticing between when they do use a proportion and a rate. The students could also write down where they come across difficulties on a problem and what they did to try to persevere through it.
- **Building Functions:** NYS Standard F-BF: The Inner Voice strategy could be applied to help students meet the mentioned standards. Students can write a function describing a relationship between two quantities and use the Inner Voice Sheet to explain their reasoning. Part of being successful in mathematics is being able to reason and justify your answers. The Inner Voice Sheet encourages students to justify their thinking. As students use the inner voice sheet in this manner they are doing Bloom's taxonomy of a higher order thinking skill of evaluating and creating.

Notes to Self:

The Inner Voice Sheet could benefit students who have ADHD or just simply find it hard to focus. The Inner Voice Sheet would even be helpful for readers who tend to read too fast because it slows them down and forces them to think about what they are reading.

Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publishers

Strategy Name: Conversation Calendar

Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publisher

What does it look like?

Memory Clue:



Steps:

1. As students read the textbook, word problems, or notes they record their thoughts, questions, opinions, and/or comments about what they are reading in the top box for the day they did the reading.
2. The students then turn in the sheet in the drop box in the classroom.
3. The teacher will read what the students wrote and respond to them.
4. Once the calendars are returned to the students they read what the teacher wrote and repeat the process over again.

Purpose:

The purpose of the conversation calendar is to keep an open line of communication between teacher and students. When students are reading mathematical text, they may have comments or questions that they want to say but if the reading is assigned for homework, they do not get the chance to voice their ideas. Additionally, teachers struggle meet with every student to see what he or she is gaining from the reading, word problem, or written notes. The conversation calendars assists students in finding the meaning within the reading because they are tracking their thinking while reading along with asking questions, which are both key to comprehension. The teacher uses the calendars to assess student needs. When the teacher responds to the questions and comments, the student can use the teachers comments to gain a better understanding about what they are reading, furthering their content knowledge. According to Johnson et al. (2011) if a student is literate in math then you must be able to have a conversation about it.

Mathematics Specific Example: pg. 20

Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publishers

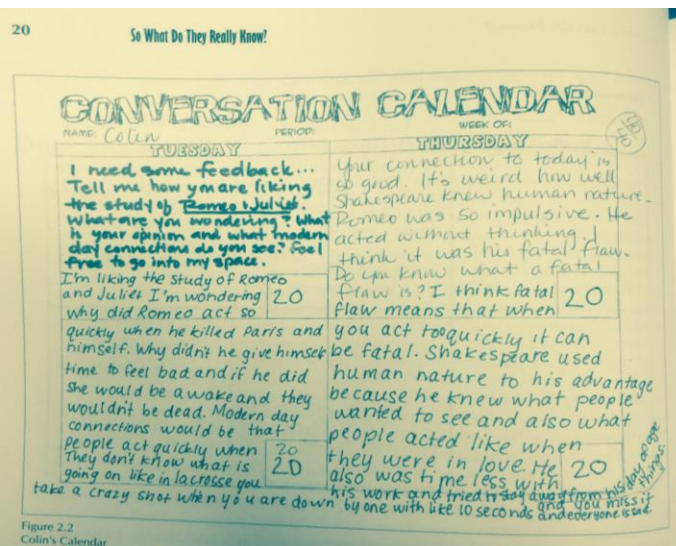


Figure 2.2
Colin's Calendar

Materials:

- Conversation Calendar
- Notes from class

Other Examples in Math:

The Conversation Calendar is versatile. I believe the most beneficial use of this strategy in mathematics class is by using it as a closure for each lesson. Students can go back through their notes from class and reflect on what they learned. Students can use the calendar to write down key concepts learned that they are confident in and also write down any confusion they may have. The teacher would then collect the Conversation Calendars and have the ability to use the student reflections to adjust his or her instruction for the next class. The teacher will also respond to each student by providing encouraging words and/or constructive feedback.

Another way for the conversation calendar to be used in a mathematics classroom is by having students; use the calendar to summarize their learning. When the calendar is used to summarize learning, students are provided the opportunity to demonstrate their understanding of the material through reciting their learning in their own words. According to Bloom's taxonomy, students are completing a lower level thinking skill when doing summarizing their learning.

Additionally, the conversation calendar can be used in a mathematics class as a "ticket out the door" or exit pass. Teachers could provide the students with a problem for them to complete. Using the conversation calendar the students complete their problem to the best of their ability to demonstrate their learning. The students are being asked to apply their learning, which is a higher-level thinking skill according to Bloom's taxonomy. After students complete the problem, teachers can provide constructive feedback in their allotted space. This allows students to learn from their mistakes immediately and will help guide teachers on how to adjust their instruction if needed.

Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publishers

Strategy Name: Annotations

Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publishers

What does it look like?

Memory Clue:



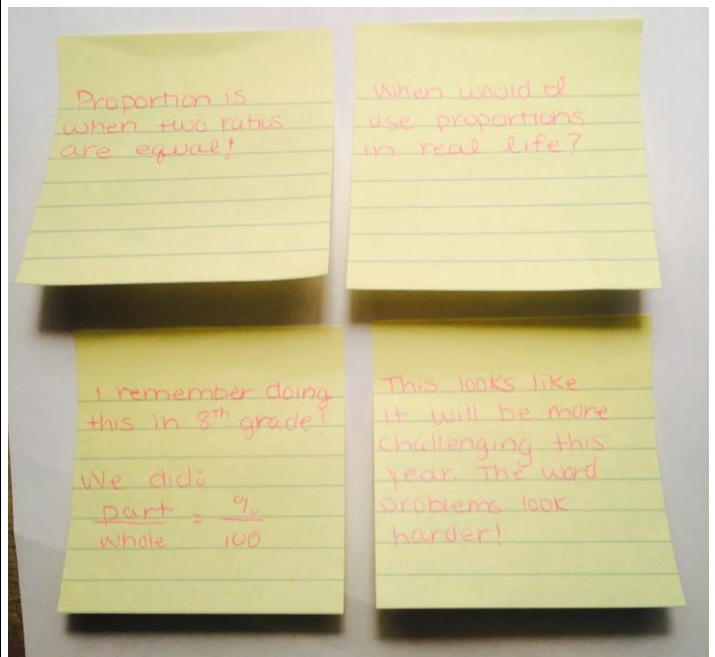
Steps:

1. Students begin to read the assigned text or complete the problems on their assessment.
2. Depending on the text and teacher requirements, students can highlight, underline, code, and/or use sticky notes to record any comments, connections, or questions the students have about the text.
3. If sticky notes are used, students pick their top 10 favorite annotations and put them on a separate sheet of paper, writing the page number the annotation came from on it to turn in to the teacher.
4. Teacher comments on the annotations and gives back to students.
5. Students review the teacher comments and can refer back to the reading.

Purpose:

Annotations are a great tool to help students keep track of their thinking as they read. Annotations also help teachers monitor who is falling behind and who hasn't read. This is helpful to math teachers because the information in the text is essential to a student fully grasping a concept. Mathematics texts are complex and many students struggle to read through it because it is so dense, which is why students must become strategic readers (Shaw, 2007). However if students were able to write down questions, connections, or indicate where something is important the text may become less dense. Students would be able to refer back to the annotations they have made after they are done reading and review what they were thinking. Another use for annotations is on tests. It would be beneficial to have students annotate their thought process as they are completing problems so teachers can understand where students are becoming confused and what they can do to help clear up confusions.

Mathematics Specific Example



Materials:

- Textbook, notes, or mathematical text
- Post-it notes
- Scrap paper

Other Examples in Math:

Just like the conversation calendar, annotations are very versatile. While annotations do not directly help students meet the New York State Common Core Standards for Mathematics, annotations does help students to think about their learning and demonstrate their thinking which will eventually lead to the students being able to complete the tasks that will result in students meeting the NYS Common Core Standards. Annotations can be used in several ways in a mathematics class. The first of which is by having students read a mathematics text and use post it notes to annotate their thinking. The students then turn in their annotations providing the teacher the opportunity to review them and see where all the students are.

The second way that annotations can be used in the mathematics classroom is by having students annotate their notes with post-it notes as the teacher is teaching the lesson. Students can write down any thoughts that come to their head such as questions or comments on their confusions or points in the lesson the students feel they are comfortable with. Annotations can allow students to go back after the lesson and look at what topics they might need to see the teacher for extra help. Additionally, Annotations aid in preparing students for any assessments in the class because students will be able to identify what they need to study.

Annotations could also be implemented in the mathematics classroom by having students annotate their homework. As students work through their homework they could use post-it notes or write on their homework questions or comments they think about as they complete each problem. This will help students remember what problems they may need help on. The annotations also assist the teacher in assessing where students are getting confused and what misconceptions are being made. Typically students will say they are confused on a problem, but teachers are not made aware of where exactly the students are having difficulty. With the annotations, teachers can better support students because they are able to pinpoint exactly where the students are getting confused.

Notes to Self:

Annotations can be used with all types of text, including pictures and diagrams. I think it would also be beneficial for students to annotate their thinking as they do assessments.

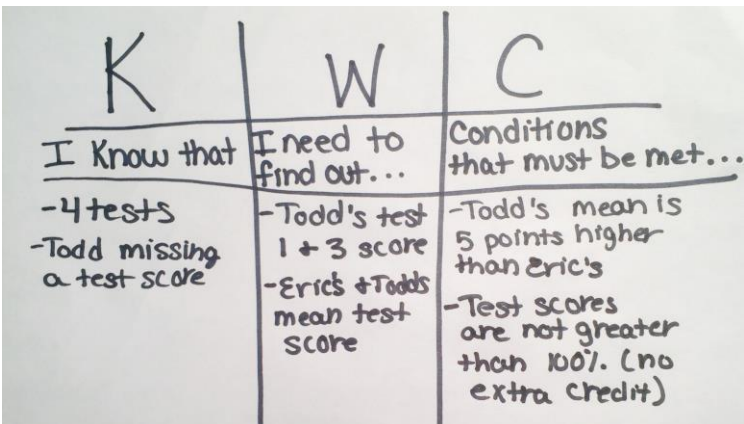
Source:

Tovani, C. (2011). *So what do they really know? Assessment that informs teaching and learning*. Portland, ME: Stenhouse Publishers

Strategy Name: KWC (Know, Want to Know, Conditions)

Source:

Hyde, A. (2006). *Comprehending math: Adapting reading strategies to teach mathematics, K-6*. Portsmouth, NH: Heinemann.

<p>What does it look like?</p> <p>Memory Clue:</p> <p style="text-align: center; color: green;">What do I know?</p> <p style="color: blue;">What do I want to find out?</p> <p style="color: purple;">Conditions or connections?</p>	<p>Steps:</p> <ol style="list-style-type: none"> 1. First students read a word problem. 2. Students then write down what they know about the problem (any given information) in the K column. 3. Next students write down what the question is asking them to determine or find in the W column. 4. Students then write down any special conditions that the problem has or connections to what procedure they must follow in the C column. 5. Next students use the information they recorded to solve the problem.
<p>Purpose:</p> <p>The purpose of the KWC is to help students organize the information they are given in the word problem and to aid them in activating their prior knowledge. The KWC is specifically designed to help students in math because it meets the needs of what the thought process students should have when approaching a word problem. According to Xin (2007), successful problem solvers are able to decide what is relevant and irrelevant in the word problem. The C column of the chart is especially important because it can help students activate their prior knowledge of rules and procedures they have learned. The KWC forces students to slow down and think about all the information the problem offers and what information is needed to complete the problem.</p>	<p>Mathematics Specific Example</p> 

Materials:

- Notebook or blank form of KWC model
- Examples/ word problems

Other Examples in Math:

The KWC strategy helps students to apply and analyze real-world problems in mathematics. Applying and analyzing are higher order thinking skills according to Bloom's Taxonomy. Students use the KWC to apply the content/skills to the real world and break information into smaller parts. Below are some examples of different mathematics topics that the KWC can be implemented with to help meet the New York State Common Core standards for mathematics.

- Ratios and Proportional Relationships: NYS standard 7.RP.1, 7.RP. 2, 7.RP.3: The KWC can be used by students to solve real-world and mathematical problems. Students can read the real-world word problem (simple interest, tax, markups and markdowns, gratuities, fees, percent increase, decrease, and percent error) provided to them and look for each part of the KWC. Students would first write down what they know from the problem, which would be the given information, then they would write down what they need to find out and any special conditions they need to know. In each of these columns of the KWC, students would identify what information or key words tell them whether they need to set up a proportion or a ratio.
- Geometry: NYS standard 7.G.6: Students would be given a question that is asking them to solve a real-world and mathematical problem that involve area, volume, and/or surface area of objects such as triangles, quadrilaterals, polygons, cubes, and prisms. The KWC strategy directly helps students to meet this standard because it helps students break down the information into smaller parts so they are thinking through the problem to be able to successfully solve it.

Notes to Self:

I believe that the KWC strategy would be beneficial to be completed by students on assessments. I would award points to students who do this. Students completing the KWC on assessments may do better because they are able to focus on the important information.

Source:

Hyde, A. (2006). *Comprehending math: Adapting reading strategies to teach mathematics, K-6*. Portsmouth, NH: Heinemann.

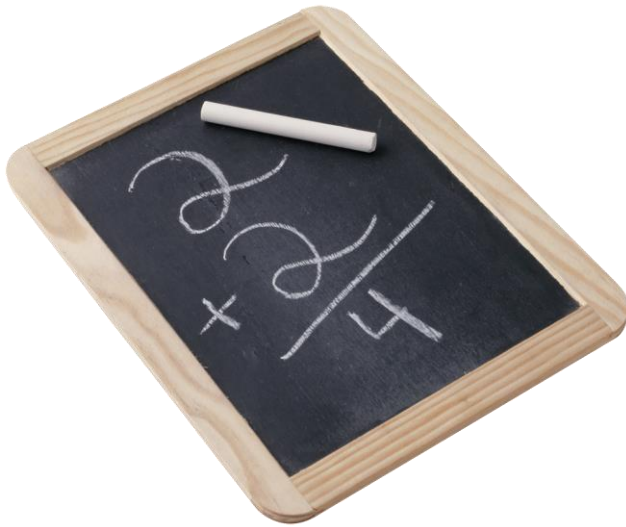
Strategy Name: Creating Representations

Source:

Hyde, A. (2006). *Comprehending math: Adapting reading strategies to teach mathematics, K-6*. Portsmouth, NH: Heineman

What does it look like?

Memory Clue:



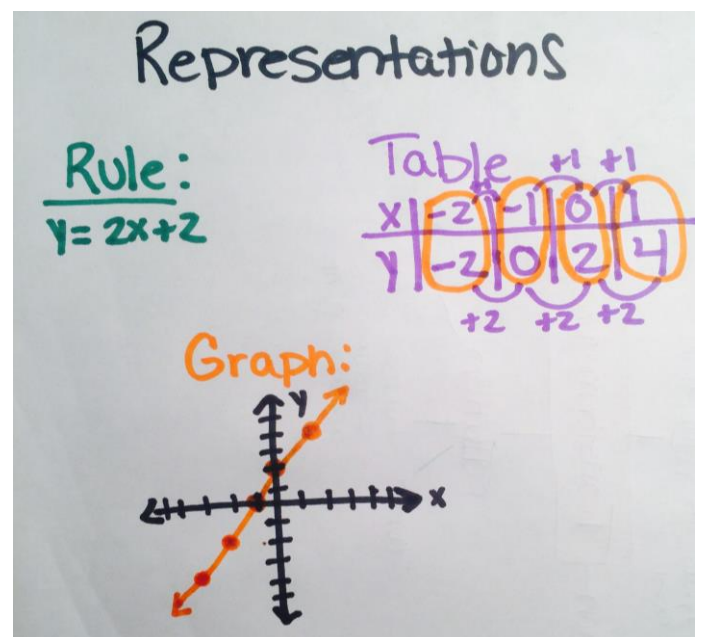
Steps:

1. Students read the problem that is given to them.
2. Students then complete the KWC (explained earlier) or record information about the problem.
3. Using the information that the students recorded, they will draw a visual representation of what is going on in the problem. Students could draw a picture, diagram, or even a graph to show what is going on.
4. After students do this they will label their picture, diagram, or graph.
5. Students then make any notes of thoughts or ideas about how to solve the problem that they had while drawing their representation.
6. Lastly students use the representation to help guide them in solving the problem.

Purpose:

The purpose of creating visual representations is to help students visually grasp what is going on in the problem and what they are being asked to do. Students need to use the text in the problem to help formulate the representation in their head and then draw it out. This helps students in comprehending what the question is asking. Some students are visual learners and will be able to better comprehend the representation than the actual written problem. Draper et al. (2012) states that text is anything that can convey meaning. When students create a representation, they are also creating their own text. By having students create a visual they are more likely to gain more knowledge on the procedures and vocabulary that are required of the problem.

Mathematics Specific Example



Materials: (note: materials depend on how you use the creating representations strategy)

- Colored pencils
- Graph paper
- Examples
- Notes
- Calculator

Other Examples in Math:

Creating Representations is a strategy that should be used in mathematics every day. The Creating Representations strategy can help teachers meet the needs of diverse learners. This allows students to see a concept written in different forms so they are able to make meaning out of what they are learning. Creating Representations may make it easier for students to learn and understand content because they see the material in different forms, depending on how each student's mind works, they can choose which representation works best for them so the student can apply it to examples/problems to be able to solve. Teachers should first model to students how to create the different representations such as tables, equations, graphs, and verbal descriptions. Creating representations can be used to guide students to meet various New York State Common Core Standards for mathematics. Below are some examples of how this can be done.

- Functions: NYS standard 8.F.1, 8.F.2, 8.F.3, A-CED.1, and A-CED.3: Students can use the Creating Representations strategy to meet the mentioned standards by first creating a table to show that for each input of a function, there is exactly one output. This can be shown in a table and by verbally stating. The students could meet the standard 8.F.2, comparing properties of two functions, by representing the function algebraically, graphically, numerically, and by verbal description. To show a function algebraically, students could create a rule to show the function. Following the rule students would be able to graph the function as another representation and they are also able to show the function numerically by creating a table by showing the x and y values of the function.
- Reasoning with Equations & Inequalities: NYS Standard A-REI. 11, A-REI.12: Students can meet these standards by taking an inequality and simplifying it first. After the inequality is simplified students could graph it on a graph to represent the function or, for beginning to learn inequalities, graph the inequality on a number line. Another way to represent an inequality is by writing it in interval notation. Before all of this can be done the teacher must first teach how to use the inequality sign to determine what features the visual representation of the inequality needs.

Notes to Self:

I would require all students to create representations for their homework assignments and practice during class. This would be optional on tests since the Creating Representations strategy may not work for every student. Creating Representations is best suited for visual learners.

Source:

Hyde, A. (2006). *Comprehending math: Adapting reading strategies to teach mathematics, K-6*. Portsmouth, NH: Heinemann.

Strategy Name: New, Knew, and Question

Source:

Gambrell, L.B. (1980). Think-time:
Implications for reading instruction.
Reading Teacher, 33, 143-146.

<p>What does it look like?</p> <p>Memory Clue:</p> <p style="text-align: center;">I knew that!</p> <p style="text-align: center;">Oooo that's new!</p>	<p>Steps:</p> <ol style="list-style-type: none"> 1. Students are assigned a reading. 2. As students read they will stop at appropriate places and record any information they read that is new to them. If students read something they already knew then students record this information in the "knew" column. If the information is new to them then students record this in the "new" column. 3. After each time students stop they will reflect on what they read and write down any "I wonder" or quiz/teacher questions that they might have thought about in the "Question" column.
<p>Purpose:</p> <p>The New, Knew, Question strategy could be used in a mathematics classroom to help students monitor their learning growth. Students will be able to identify what information they read is new, what information they already knew, and what questions they might have about what they read. The New, Knew, Question strategy will require students to think deeply and activate their prior knowledge in order to separate the "new" information from the "knew". Often in math instruction the material students are learning and reading relates back to the student's prior knowledge and linguistic experiences in mathematics (Rojano, et al., 2014).</p>	<p>Mathematics Specific Example</p> <p>New: I now know how to find mean, median, minimum, maximum, and standard deviation on the calculator.</p> <p>Knew: I knew how to find mean, median, mode, and range by hand with out the calculator.</p> <p>Question: How can I make the calculator actually graph a box and whisker plot?</p>

Materials:

- Mathematical text or problems or notes
- New-Knew-Question organizer

Other Examples in Math:

The New-Knew-Question strategy can be applied to almost every topic in mathematics and can be used in various ways. One way the New-Knew-Question can be used is during the reading of the textbook or some other mathematical text. Since mathematics learning tends to build off of previous mathematical concepts that are learned, students can use the New-Knew-Question strategy to help activate their prior knowledge. As students read the mathematical text they can identify the material they already knew and make note of it. Students will also write down any new information they learn. Additionally, students write down any questions they have.

The New-Knew-Question strategy can also be used during class time as students are presented the content for the lesson they are being taught. Students can keep track of the new information presented to them in the “New” section of the strategy. As students and the teacher work through any mathematical problems, students can write down any information or steps they took to solve the problem they already knew how to do. For example, when teaching simplifying inequalities, students must apply their previous knowledge of solving equations. In the “Knew” column of the strategy, students would write down the steps they already knew such as “get all variables onto one side” and “get all real numbers to one side”. For the “New” section of the strategy, students would write down “when dividing or multiplying by a negative number, you must reverse or flip the inequality sign”. Students would then put any questions or confusions they have in the “Questions” column. The New-Knew-Question strategy will help students to solve one-variable inequalities and compare solving equations to solving inequalities.

Notes to Self:

The New, Knew, Question strategy could be done individually in the classroom during independent reading or even as a homework assignment.

Source:

Gambrell, L.B. (1980). Think-time: Implications for reading instruction. *Reading Teacher*, 33, 143-146.

Strategy Name: Most Important Word

Source:

Bleich, D. (1975). *Reading and feelings: Introduction to subjective criticism*. Urbana, IL: National Council of Teachers of English.

What does it look like?

Memory Clue:



Steps:

1. As students read the assigned text, they will stop at appropriate places and determine the most important word according to them or the author.
2. Students record the word in the “Important word” column of the worksheet.
3. Then in the “Why is it important column” they right down why they thought it was important and the definition of the word.
4. Students can get with partners and discuss the words they discovered and compare with each other which ones they thought were important and why.

Purpose:

This strategy can be used in a mathematics classroom to help students keep track of academic vocabulary and gain further content knowledge. With this strategy, students will identify the most important words in the text they are reading; most likely these will be vocabulary words. They then will write why this word is important and the definition of the word. This will allow students to keep the words they are learning in one spot and essentially will help them create their own personal dictionary. This strategy can also be done with word problems. Successful problem solvers are able to decide what information is relevant and which is not (Xin, 2007). Students would use this strategy to identify the important words/information within the text to help them solve the problem.

Mathematics Specific Example

Most Important Word	Why is this word important?
Equation	This word is important because I have to know the difference between an equation and an expression. An equation is a mathematical statement that includes an equal sign!

Materials:

- Notebook
- Mathematics text, notes or problem

Other Examples in Math:

The Most Important Word strategy can be used with various mathematics topics to help students meet the New York State Common Core standards. While the Most Important Word strategy does not directly help students meet the standards, it provides the appropriate building blocks for students to build up the skills to meet the mathematics standards. In order to be able to apply and evaluate their knowledge and skills students must first understand the key concepts and what they mean. The Most Important Word strategy can be used in several ways. One approach teachers can use with the Most Important Word strategy to help students access the content presented in mathematical text is through a reading. Since mathematical text is dense, students tend to have a hard time identifying the key information. As students read they can identify the most important word in each paragraph or page; allowing students to recognize the key information in a mathematical text, which will increase their comprehension.

Another approach teachers can use with the Most Important Word strategy to help students access content through is by having students use the strategy with real-world word problems. The first step to solving a word problem is reading it and identifying the important information. In word problems there are certain words that tell you what to do. For example, if students are dealing with a word problem where there are words such as maximum, minimum, at least, or at most then students know they are dealing with a problem where they need to set up an inequality. Each of the words mentioned are important words that tell students which inequality sign they need to use and how to set up the inequality.

Notes to Self:

The Most Important Word strategy would be good to use when teaching a new topic. The whole class could do this together. As we read a text, students can raise their hands and tell the class what words they think are most important and why.

Source:

Bleich, D. (1975). *Reading and feelings: Introduction to subjective criticism*. Urbana, IL: National Council of Teachers of English.

Chapter 4: Conclusions and Implications

Introduction

Based on the research conducted, I was able to answer all three of my initial research questions. My research questions were:

- Why do students struggle to read mathematics text?
- What can teachers do to help students in accessing text?
- What are literacy strategies that can be modified and used in mathematics instruction to aid students in gaining a deeper conceptual understanding of the content knowledge within the text?

In the literature review I was able to conclude why students struggle to read mathematical texts. Students struggle mainly because of text complexity, but also because they were never taught how to read and write like a mathematician. The way a person reads and writes mathematically is different than how they would read print text. In order for teachers to be prepared to teach students how to read and write mathematically, they have to redefine what “text” is in terms of math class. As stated before, text is considered to be anything that can convey meaning (Draper et al., 2012). Besides redefining text, teachers can assist students in accessing the text by collaborating with the literacy specialist at their school or by using the strategy toolkit I have created for the curriculum design. The strategy toolkit is a list of strategies that can be used to help students become more strategic readers in mathematics. Shaw (2007) suggests students become strategic readers because as they move up to the higher levels of math, they will notice that the text become more and more complex. Being a strategic reader and knowing how to employ mathematics specific literacy strategies will aid students in becoming independent and read like a mathematician would.

Conclusions

To develop my strategy toolkit I reviewed the reasons students struggle to read mathematical text. Based on these reasons, I was able to choose strategies I believed would meet the needs of mathematics students. The strategies I found most beneficial for students comprehension and learning of mathematics are: Jigsaw, Triple-Entry Vocabulary Journal, Frayer Model, Graphic Map, Inner Voice Sheet, Conversation Calendar, Annotations, KWC, Creating Representations, New Knew Question, and Most Important Word. As I decided which strategies would best fit into mathematics instruction, I found there to be several themes among the literacy strategies. The themes I found consisted of the way I grouped the literacy strategies. The literacy strategies I deemed beneficial for mathematics fell into one of the three themes: chunking, vocabulary, and key concepts.

Chunking. I found several of the strategies I chose helped students to chunk information. These strategies were chosen to help students break down mathematical text since the texts are dense and complex (Massey & Riley, 2013). When students are presented with these types of texts, the texts become daunting to students and students begin to shy away from reading them (Shaw, 2007). The strategies I picked that would fall into this theme are: Jigsaw, Creating Representations, Graphic Map and the strategy New, Knew, Question. All of these strategies help students to break down a text and chunk the information into smaller parts so they are able to comprehend and pull meaning from the text.

Vocabulary. The second theme I found was in vocabulary. As I looked through my strategy toolkit I saw I had chose various strategies that specifically aid students in vocabulary. The strategies I found to fall into the vocabulary category are the Frayer Model, Triple-Entry

Vocabulary Journal, and the Most Important Word Strategy. Hawkins (2014) explains that students need clarification on words, symbols, and phrases before students can rewrite them in mathematical terms. If students are unable to understand mathematical terms in the text, they will not be able to use them to communicate and to comprehend the text. This would hinder students' conceptual understanding of the mathematics content. The strategies that fell into the vocabulary category are meant to help students gain a deeper understanding of what each vocabulary word means so they are able to identify it and use the academic vocabulary to speak, read, and write like a mathematician would.

Key Concepts. The strategies I found to match the key concepts theme are inner voice sheet, conversation calendar, KWC, and annotations. The KWC helps students with their problem solving skills by chunking the information in the problem presented to them. Xin (2007) explains that problem solvers are most successful when they are able to separate the relevant information from the irrelevant. Both the KWC and the annotations strategies help students identify relevant or important information within a text. According to Johnson et al. (2011) if you are literate in math then you must be able to have a conversation about it. The inner voice sheet and the conversation calendar are both strategies that help students break down a text by pulling out the key concepts that stuck out to them and communicating their thoughts. Since both strategies assist students with tracking their thinking as they are reading, they are able to read a little bit of the text at a time then stop to record their thoughts. The benefit to the conversation calendar is that the teacher is able to respond to the students thinking on the conversation calendar.

In response to the results from my literature review and the curriculum design, teachers and other professionals should use the strategy toolkit created as a resource of strategies to

implement into their mathematics instruction. According to Dew and Teague (2015) there are two components teachers need to do in order to successfully create a disciplinary literacy rich environment. The first of which is selecting the literacy strategies. Teachers need to intentionally choose which strategies they are going to use (Dew & Teague). This is not something that can be done without putting some thought into it. Teachers need to choose literacy strategies that will help their students meet the goal the teacher has set for them. By doing this, teachers are setting students up for success in their learning. The second component to creating a disciplinary literacy rich classroom is to choose where in the lesson the literacy strategies will be implemented (Dew & Teague). Teachers need to think about whether the strategy will be used at the beginning, middle, or end of the lesson. By intentionally placing the strategies in the lesson, teachers can gain insight into student understanding, which later on can guide their instruction (Dew & Teague).

Limitations

The limitation of this study is that the strategies I chose have not been tested on adolescent mathematics students, so these are not proven to work to specifically improve mathematics students' abilities. The toolkit is based on the research I have done and my knowledge of mathematics and literacy instruction.

Research Suggestions

Based on the results from my research I believe that further research can be done by testing these strategies on adolescent mathematics students. Collecting data on student growth when students are using these strategies would be beneficial to determine if these strategies truly help improve students' conceptual understanding of mathematic concepts.

Overall Significance

The findings of this Curriculum Design has provided insight as to why adolescent students struggle to read, comprehend and write in mathematics class. This Curriculum Design brings to light various strategies that can be used to help students with the areas of weakness that was discovered through research. The findings from the research can be implemented by teachers in their mathematics instruction to help students gain a deeper conceptual understanding and access the content presented in the mathematical text.

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