**Vocabulary Instruction of Mathematics Material
 to Improve Reading Comprehension**

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**Background Information**

The student of focus in this case study was T.J. This 17 year old boy had just completed his junior year of high school. Living in an affluent part of Southeastern Michigan, T.J. was adopted by his parents when he was a toddler from the Country of Russia. The orphanage claimed that he came from a single mother who had substance abuse problems. As a result, T.J. had cognitive development issues from the beginning. For example, he didn’t to speak any form of verbal language until the age of four. It became obvious quite quickly that he would need additional help to succeed in academics. He was tested and then subsequently labeled as a “special needs” students. He received remediation in school and his family hired private, professional tutoring. By third grade a large improvement was observed, until the family was uprooted to China, due to T.J.’s father’s affiliation with the automotive industry. They stayed for four years. Schooling was done at an international program. Remediation, accommodations, and private tutoring were again tools that were implemented to aid in T.J.’s success. Upon return to the United States, T.J. was enrolled in an alternative school specializing in gifted/talented AND special needs students. T.J. remained there until the end of his sophomore year. Due to his success at the alternative school, he transferred to the public school in the district that he lives, where he is on track to graduate in 2012.

I have known the student for three years. We are neighbors. In addition, I had tutored T.J. in mathematics for the past year, so there is some prior knowledge of the student’s literacy level on my part.

The family is of high socioeconomic status. Both parents graduated from college and have high expectations in terms of education. T.J. has two older siblings. Both were born naturally to the family. Both are on track to graduate from college. One has recently graduated from a well known in state college, earning an undergraduate degree in physics as well as a master’s degree in mechanical engineering. The other is a senior at a Swiss University that specializes in hospitality management. Both siblings earned college scholarships as a result of their high school experience and have had no cognitive development issues growing up.

As a child, T.J. was read to by his parents. There was a particular focus between the ages of two and five in an attempt to begin/increase his verbal skills. Reading books were encouraged by his parents. Initially T.J. was interested in books, in particular picture books. He liked to have them read to him. In addition, he made up stories based on the pictures in the books. He struggled with recognition and pronunciation of site words. Over time, T.J. shifted interested in reading personal books to playing video games.

As I began to work T.J. on this case study, the question of, “What was the last non-school book that you read?” was presented to T.J. He responded with, “Ha ha, very funny… why would I want to read a book, when I can go see the movie?” When pressed further, he responded by indicating that it was either *Harry Potter* or “one of those *Twilight* books, but don’t tell anyone… I don’t want to get made fun of.” As one can see, because of tutoring, a caring and safe learning environment had already been established between the two of us (Standard IV).

Emotionally, T.J. can be described as a “typical” teenager, socially speaking. Academically speaking, there appeared to be a certain amount of emotional duress. He did not exhibit traits on an intrinsic learner as he made comments throughout our sessions that he would rather play soccer or hang out with his girlfriend than be in school or do school related work. During tutoring, he was easily frustrated as he would have to do work twice due to the fact that he frequently misread/didn’t read/couldn’t read the directions. T.J. revealed during one session that in school he went to his resource room teacher to take tests, where they would read the directions to him. He was allowed to use notes that had example problems, vocabulary words and definitions, etc… when taking his assessments. Further, general memorization of basic mathematics facts was missing. For example, when asked what seven times eight was, T.J. reached for his calculator. When asked not to use the calculator, he struggled to come up with 56. He answered incorrectly twice, and then took a short period of time to collect himself before answering correctly. In general, there was initial disdain for the material exhibited by T.J. most every time a meeting occurred for tutoring. By the end of each session though, T.J. was in good spirits as he felt as though he “got it”. He earned a B- on his final exam.

**Initial assessment**

 It was quite obvious to me that a significant impediment to success in the Algebra material being reviewed was, in part, literacy based. As the cumulative student record folder (CA 60) was not available for me to peruse, baseline testing was necessary. First the San Diego Quick Assessment (Artifact 1) was used to obtain a general reading level. Testing began with ten words written on an index card (see the appendix for all of the words). Since the student is enrolled in 12th grade, a list of tenth grade words began the assessment. The student experienced frustration, mispronouncing five of the ten words on the list (zany, nausea, gratuitous, legality, and amnesty). From there, the student further experienced frustration mispronouncing four of the ten words on the ninth grade list (conscientious, kinship, conservatism, and jaunty). T.J. was deemed as instructional based on the eighth grade list as he mispronounced only two words (capacious and acrid). He is considered independent based on the seventh grade list as he pronounced every word correctly on the list. Based on this assessment, T.J. appears to have a seventh to eighth grade reading level.

From there, I wanted a concrete mechanism to assess T.J.’s reading comprehension level. In particular, based on the accommodations being offered through the special education department at his home school, the examiner wanted to determine the risk level of the student’s reading comprehension, as it appeared to be quite severe. The High School Vocabulary Maze Assessment Risk Profile (Artifact 2) was administered. This assessment was developed by the Florida Center for Reading Research. It has two passages for the student to read. In each passage every seventh word is replaced with a word choice. The word choice is composed of three words: one correct and two distracters. Distracters must be within one letter in length of the correct choice and do not place high demands on comprehension. However, students must monitor the general meaning of the passage to select the correct response. The student has three minutes to complete each passage. In the first passage the student finished with plenty of time. In the second passage, the student struggled to finish in the allotted three minutes. It appeared that T.J. rushed the last paragraph of the William Penn passage. Overall T.J. averaged 31 correct responses; based on the rubric provided (Artifact 3) he was of medium risk for his grade level. This is rather surprising, as his accommodations would indicate a high risk scenario.

# **Design of Case Study**

 The direction that I decided to follow after obtaining these two pieces of information was to focus on developing T.J.’s ability to understand mathematical vocabulary, and his ability to comprehend what he was reading as a whole (Standard III). Stahl stated, “Good readers are more able to derive word meanings from context than struggling readers.”(1992). Therefore, lessons to assess T.J.’s contextual knowledge of correct mathematical vocabulary words and their meaning must be implemented. Directed exposure to words helps to increase vocabulary instruction (Stahl 2003). Direct instruction plays a more important role in obtaining vocabulary for struggling readers (Stahl 1992). I worked with T.J. on a one on one level; I provided for both directed exposure as well as direct instruction to facilitate an increase in vocabulary knowledge of technical textbook materials.

 I chose to use T.J.’s Algebra Textbook as a resource for my first lesson (Artifact 4). Initially, I was going to make copies of a section that he struggled with during tutoring. I knew that he had prior knowledge as I had worked with him on it in the spring. Further, he didn’t do well on this section based on his assessment grades from his mathematics teacher. I was going to have T.J. use a red/yellow/green color coding system to let me know what portions of the text he understood (green), what portions were fuzzy (yellow), and what portions he absolutely did not understand (red). Unfortunately, I couldn’t find any research to back up this technique in terms of its effectiveness with vocabulary comprehension. Instead, I decided to use the KWL Chart (Artifact 5) to accomplish the same goal. I had T.J. read the text focusing in the words of the text and their meanings, rather than on the mathematics associated with them. Under the “What I know” column he placed the terms exponent, add, multiply, and base. When asked to provide the correct definitions, he did so without a problem. Under the “What I want to know” column, he placed the terms product of powers property, power of a power property, and power of a product property. When I asked what he wanted to know about those terms he responded by asking why they had the same thing three times in a row. He thought that those were just different ways of saying the same thing. He used prior knowledge and indicated that this had messed him up before, so he just skipped it and went right to the problems. I had him slow down; I asked what each word meant on its own. “Product- when you multiply” “Power – that’s the exponent” “Property- that’s like a law or something…” I asked him to put them together and he couldn’t, claiming that it didn’t make any sense. Knowing that T.J. was a visual learner (Standard 1), I directed him to an example problem in the textbook: 53\*56. I asked him to then put it together. He again identified each piece separately, so I showed another example problem: x2\*x3\*x4. He looked at it and stated that it wasn’t helping him understand the vocabulary, so I stepped in and asked what he noticed was similar about each of the problems. He answered in a shallow manner, the both have multiplication and they both have exponents. I directed him to the bases… he indicated that they were all the same in each problem. From there I asked him what could be done since the bases were the same… he told me that they could all be combined together. I asked how… he replied with you either add up the exponents or times them. I asked him what should be done with the bases… he wasn’t sure, but thought that they remain the same. I then had him write each problem out without exponents (5\*5\*5\*5\*5\*5\*5\*5\*5) and (x\*x\*x\*x\*x\*x\*x\*x\*x). I asked him tell me how many fives there were… he said nine. Then his eyes got big and he wrote 59 and x9.
“Oh I get it, this is like the same problem… when you are timesing the same bases together with different exponents, you just add up the exponents… I remember that now!” We high fived and then I directed him back to the vocabulary term. He decided that it should be called product of same base rule, as it made more sense to him.

Initially I was worried that we wouldn’t finish the lesson, but things went more smoothly from there. For power of a power property, he said that was when it had two exponents with it and pointed to the example problem: (33)3. I informed him that he was correct. A further discussion occurred as to the correct mathematical approach. Using a similar approach as was mentioned earlier, he figured out that the exponents get multiplied with the property. By the time we got to power of a product property, I knew that he would be fine with what the words meant. However, as Stahl stated, “Simply recognizing a word means nothing, if you do not know what it means.” (2003, p. 246) Though T.J. correctly stated that here things were being multiplied and then raised to a power, I asked what that meant mathematically. He pointed at the example: (32xy)2. I asked what should be done. He said that we maybe should add them. So we again wrote out (32xy)\*( 32xy) and then 32\*x\*y\*32\*x\*y and then 32\*32\*x\*x\*y\*y and finally 34\*x2\*y2. He then remembered that this property meant that the exponent got “dirstributed” (his pronunciation) to each of the bases. I noticed that an understanding of the vocabulary didn’t correlate to and understanding of the mathematics involved to solve each problem. He indicated that before it was just a bunch of words that started with “p”, now he was actually thinking about what each word meant. Most importantly he was now thinking about how it applied. It is this application to the “real world” that demonstrated T.J. increase in vocabulary literacy (Guthrie, 2004).

When decoding a mathematics textbook, it isn’t enough to simply understand what is written, one must also be able to apply that knowledge with the mathematics that is involved. It is this type of synthesis that students often struggle with. Therefore the next part of the lesson involved connecting the terms with something applicable to the real world. (Standards I & II) The following question was asked: You are taking a math quiz with 10 multiple choice questions (A, B, C, D) and 10 True or False questions. How many different ways can you fill out the multiple choice section… state your answer in exponential form. At first he said 40, then without prompting he realized his error, and said 410. Next I said, what if there are two different versions of the same quiz… he says (410)2. At this point I asked what property was being modeled; he stated power of a power. We again high five. I asked how many ways that was… he smiled and said that he’d need his calculator for that. After a moment he looked at me and said,

“Whoa, you just blew my mind… up ‘til now, I never thought exponents had ANYTHING to do with real life. I thought it was just nerdy stuff, but like, it’s used for like lots of stuff… like maybe banks and money and stuff, and even video gaming.”

My actual assessment involved comparing and contrasting the product of powers property with the power of a product property. (Standards II, V, VI) T.J. was encouraged to use examples or draw pictures. His answer was spot on! He indicated that they both have to do with multiplying and exponents, but with products of powers you add the exponents and with power of a product you multiply. He even made up his own examples. He left claiming that this stuff was easy and wished that he had me as a teacher.

For the second lesson, I wanted T.J. to focus more on the connection between the vocabulary words and their mathematical implications. Therefore, I chose a topic that was new to him. I did this as a wanted to see what prior knowledge he could bring to a “new” concept. In addition, my goal was not only to create a deep understanding of the vocabulary word(s) for this particular lesson, but also to provide T.J. with tools that he could use going forward in ANY subject matter (Standard II). To achieve this required depth of vocabulary understanding, the lesson plan needed to approach the topics in a variety of ways. To accomplish this, a Vocabulary Word Map (Artifact 7) was the focus of the lesson. Here, T.J. began by looking at the words that I had written in the middle of the graphic organizer, “trigonometric ratios.” He was asked to write down his own definition of the words in the appropriate space. Next, he looked up the term in the back of the book and wrote that definition in the appropriate space. I then asked T.J. to anticipate where we were heading. He responded with, “Right triangles… I like those.” I had him brainstorm and come up with everything he knew about right triangles. He discussed the legs, the 90 degree angle, and the hippopotamus (the word was supposed to be hypotenuse… I smiled, corrected him, and had him say the word properly), and even the formula a2 + b2 = c2. It is important to show students how to connect with their own prior knowledge as it is a skill that many struggling readers lack, even in high school (Newell et al, 2007).

We then opened the textbook to the section on trigonometric ratios. Now that T.J. knew what his purpose was (to figure out the three basic ratios known as sine, cosine, and tangent), his reading was quite focused. While reading he didn’t understand what the word “adjacent” meant. Rather than tell, him I asked what sorts of strategies he had learned thus far. He thought for a moment and then stated that he remembered hearing the word before in class, but because he couldn’t pronounce it, he didn’t bother to learn it. He didn’t recognize a root word, a prefix, or a suffix. When pressed for his definition he came up with “around something”. I again accessed his learning strength by going to a picture where it had the adjacent side labeled. Further I listed the words adjective, adjunct, adjoin, and adjust. He thought that the “adj” must mean a part of something else, so the term adjacent meant that is was part of the angle, so in the picture it was the side “touching” the angle. He then asked how to you know which side to call adjacent since there are two. He realized that the other side would always be the hypotenuse… this lead to a smooth transition to the ratios themselves. I used the mnemonic device of SOH-CAH-TOA to help him. After a short time, he understood first letter was the name of the trigonometric ratio (sine, cosine, or tangent); that the second letter corresponded with the numerator of the ratio (side opposite the angle or side adjacent to the angle); while the third letter corresponded to the denominator of the ratio (opposite, adjacent, or hypotenuse). T.J. showed very quickly through practice problems that he understood the concept, so I again went to the compare and contrast question. Compare and contrast the sine of a right triangle with the cosine of a right triangle. He did well by answering that they were both fractions, but the sine used the opposite side, while the cosine used the adjacent side. He drew a picture to explain.

# **Reflections of Literacy Instruction**

In general, I thought that I made a meaningful contribution to the student’s overall reading progress. First, I showed T.J. that it is in fact important to read the textbook in a mathematics class (this was something that hadn’t been stressed to him.) In addition, I modeled (or in certain instances reminded) a variety of strategies for T.J. to employ whenever he came across difficult text. These strategies included accessing prior knowledge; looking for known root words, prefixes, and suffixes; applying the text to “real world” scenarios; look for similarities and differences between vocabulary words; and using the student’s learning strength(s) to aid in content knowledge. In addition, I was able to monitor and repair understanding via personalized directed practice and good questioning strategies (Ehren 2005). I also believe the lessons were successful because I integrated comprehension with vocabulary knowledge, which is known to have a strong connection (Ehren 2005).

I had to make some critical choices during both lessons. In the first lesson, I chose to direct T.J. towards the multiple choice question as I could tell that he was memorizing not synthesizing. This wasn’t something that I had scripted. It was as a result of this spur of the moment change that I got the “you just blew my mind…” comment. That wouldn’t have happened had I followed the lesson plan. The second thing that happened was that I realized that in order for T.J. to bridge the gap between vocabulary understanding and content knowledge, I had to be quite visual in my approach.

There were so many things that I would change about the lessons that I taught. The first is that I would have liked to have done it during the school year, in my classroom. At the end of the day, I am a mathematics teacher and would have loved to have been able to do the case study in a more organic way. Many of the readings gave specific advice as to how to allow students to help each other. I am quite fond of trying these techniques, as this IS the best way that I can help my students with increasing their literacy skills.

Further, this format of a case study didn’t allow for sustained knowledge over time. Most cases studies that I have seen are at least a year in length. Due to the time limitations of this course, I felt that the increase in knowledge that was assessed was short term in nature. It would be interesting to see what “stuck” after a month or two. As a result, I can’t say with confidence that T.J. achieved my instructional goals. I do feel confident that he is on a better path to success in a class that relies heavily on the usage of a textbook, as a result of the two hours that I spent with him.

If I were to teach these lessons to T.J. again, there isn’t a whole lot that I would change, in terms of the interaction between the two of us. I had no behavior issues. In fact, he was quite interested in “helping” me. He was particularly curious to see what type of grade I get on this paper. I assured him that he did a fantastic job and that if I got a less than stellar grade it would be my own fault. I will say that in terms of the data I collected, while useful, it isn’t simply a bunch of numbers that can be typed into a data base and looked at a later date. To get good data, more students (my preference) or more time would be necessary.

To me, T.J. is a remarkable kid, who through the help of his parents has overcome a great deal of cognitive difficulties. He is a reminder that building a safe and caring environment for learning is imperative. In addition, tasks should be broken into smaller segments as he becomes frustrated if he feels that job is too large for him to handle.

Because of this course I learned SO much about how to provide effective reading instruction. The first is to actually break down the words into the smaller pieces. Next, compare them to other similar (or different depending) sounding/looking words. In addition, I learned why students struggle with literacy in general. I need to expose students to more text (not less). Further, I learned how to model many of the good traits that I “own” as a good reader. I also learned that for a high school teacher of mathematics, I did have some good intuitions when it came to help with student comprehension. After all, a best practice should and will transcend content areas. Finally, I believe that many of the techniques that I employed with one “struggling” reader would be beneficial to use in a whole class environment.

**Recommendations for T.J.**

For those who continue to work with this student on his literacy skills here are some suggestions:

* Start with something small and then lead into the overarching idea(s)
* Access his prior knowledge first, you’d be surprised at what he already knows
* Pronunciation is intimately connected with his ability to understand the word(s); don’t allow him to skip over important vocabulary
* When he comes across unfamiliar text, guide him towards breaking words down into their smaller pieces
* His initial response is, “I don’t know”; he does this to see if you’ll tell him the answer.
* Be patient, he needs more time than most students
* His learning strength is quite visual in nature; be sure to use visual queues and graphic organizers
* He loves movies, ports, and video games; guide him to read/write about these topics whenever he has a choice

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