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A Transdisciplinary Approach to Reading: In Mathematics, Remedial Reading, and Biblical Exegesis[1]

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ABSTRACT

This paper studies reading comprehension in three distinct disciplinary settings: Mathematics verbal problems, remedial reading, and biblical exegesis. This transdisciplinary approach enriches our understanding of reading, enabling focus on key methods of improving reading. The transdisciplinary approach also affords us new insights into addressing equity issues. The paper's approach is influenced by Meyer's seminal work on textual organizational structure as a key method to achieve reading comprehension. Consistent with this approach, the paper advocates using signal words or keywords, as well as listing and teaching organizational structures as a means to improving literacy in reading, mathematics, and biblical exegesis. The paper recommends that these techniques should be a primary method of approaching math and biblical fluency.

Keywords: mathematical verbal problems, biblical exegesis, textual organizational structure, signal words, keywords,

1. A SIMPLE EXAMPLE

The critical place of reading comprehension in education should be obvious. Reading for understanding is vital for readers of all ages. Comprehension of expository text is necessary for academic success in school [24]. Nevertheless, the 2009 National Assessment of Educational Progress [31] reported that 33% of 4th-grade students examined could not read at the basic level required to understand what they read.

This paper studies reading in three disciplinary settings: reading deficiencies in segments of the American population, reading deficiencies impeding solving mathematical verbal problems, and reading deficiencies interfering with understanding the bible. However, the literature on remediation is quite vast. Therefore, to illustrate our approach we start in this section with a simply described example. After presenting the example and having something concrete to point to, we present the underlying theory. We then approach mathematical verbal problems and biblical exegesis, using this underlying theory.

1.1 Three sentence pairs. Padua [26] gives the three sentence pairs presented below as illustrative of items challenging to 5th grade Pacific Islanders. The particular material comes from a successful skills-based professional development program, Pacific CHILD, (Pacific Communities with High Performance in Literary Development) [26] The three sets of sentences are as follows:

(1a) The window was left open during the heavy rain. Therefore, the bedroom rug was soaked
1b) The bedroom rug was soaked because the window was left open during the heavy rain.

(2a) As a result of strong winds the roof flew off the house.
(2b) The roof flew off the house as a result of the strong winds.

(3a) I woke up late. Therefore, I missed the bus.
(3b) I missed the bus since I woke up late.

1.2 Analysis: In these three sets of sentences, the sequence of phrases in the (a) sentences corresponds to the correct cause and effect order, while the sequence of phrases in the (b) sentences reverse the correct cause and effect order. For example, in (2b) the fact that the roof flew off the house (the effect) is stated *before* the statement of strong winds (the cause), while in (2a) the strong winds (the cause) is stated *prior* to the statement that the roof flew off the house (the effect).

While many adults and children equally understand both the (a) and (b) sentences, certain 5th grade Pacific Islanders (and for that matter other groups of people) find the (a) sentences easier to understand than the (b) sentences. The reason for this disparity has to do with the cause-effect organizational structure of the texts. The good readers understand that the sentences display a cause-effect organizational structure while the poor readers do not understand this.

1.3 The Types of Textual Organizational Structures: Meyer and her doctoral students along with several other researchers have championed the idea that textual organizational structure is critical and primary for reading comprehension. This idea has been explored over 50 years in a wide variety of settings [17] including i) a variety of age groups, including children, teenagers, middle-age folks, and older adults [2, 9, 16,19,23,30,32], ii) several languages [18,28], iii) a diversity of educational settings including 5th grade, 9th grade, general K-12, English as a Second Language, community colleges, university teaching, and gerontology [1,4,7,8,14,22] iv) different subject matter disciplines (scientific, social studies, and narrative) [3,29], as well as v) with and without related assistive techniques such as use of signal words also known as keywords, clues, or cue words, or the use of technology with and without various forms of feedback [15, 21,22].

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As a result of this research, a variety of high-level textual organizational structures have been identified. Meyer originally noted five types of organizational structures among narratives: i) cause-effect, ii) problem-solution, iii) comparison, iv) antecedent-consequent, and v) collection. The latest research [17] suggests adding a 6th category, *description.* Cook and Mayer [3] separately list five types of text structure used in the sciences: i) generalization, ii) enumeration, iii) sequence, iv) classification, and v) compare/contrast

The textual organization structure approach is based on the following premises: *Students' comprehension is improved when they understand the text features (the physical presentation of the text) and the text structure (the way authors structure or organize their writing) Students who are knowledgeable about and/or follow the author's structure in their attempts to recall a text remember more than those who do not [5,6]. In addition, more good than poor readers follow the author's structure in their attempt to recall a text [27]. Once students understand that text structures exist and what the major ones are, they can use strategies, such as graphic organizers and signal words, to help them structure the text of their own writing.*

Padua herself [26] uses multiple strategies for remediation including i) organizational structure, which was just mentioned, ii) signal words, iii) visual representations, and iv) consideration of more sophisticated organizational structures (for example, examples (1)-(3) illustrate single cause-effect while frequently narratives have multiple cause and effect.) For illustrative purposes, to present our main point of organizational structure, the examples in this section suffice.

2 BAYES THEOREM

The reading problems associated with the mathematical topic, Bayes Theorem, present several instances where reading comprehension is critical to solving the problem. This section shows that the issues of mathematical reading comprehension are identical with the reading issues in the Padua remediation example presented in Section 1. We begin by presenting the formal content of Bayes' Theorem [13].

2.1 The Formalism Underlying Bayes Theorem: To illustrate Bayes' Theorem we consider the hypothetical case of planning a picnic on a certain day but discovering that morning that it is cloudy. We naturally ask if rain is expected. Symbolically we wish to compute

Pr(Rain | Cloud) = Probability of it Raining given that it is cloudy

Here the vertical bar | is the mathematical symbol for "given" and "Pr" is the mathematical symbol for probability . Bayes' theorem states that the above probability can be calculated as follows

1) Pr(Rain|Cloud) = Pr(Cloud | Rain) * Pr(Rain) / Pr(Cloud)

Where

- *Pr(Cloud) is the probability or percent of days beginning cloudy
- *Pr(Rain) is the probability or percent of days when it rains
- *Pr(Cloud | Rain)= Probability of it being cloudy that morning given that it rained during the day.

2.2 A Bayes Theorem Word Problem. In this and the next two sections, we consider three versions of the same word problem. In version 1, the English exactly mirrors the mathematical notation .

Version 1: The probability of rain is 10%. The probability of cloudiness (in the morning) is 30%. The probability that it is cloudy in the morning given that it rains that day is 75%. I wake up on a day I plan for a picnic and find it is cloudy. Calculate the probability of rain that day, given that it is cloudy.

2.2 Model Solution. Table 1 presents a model solution to this problem; all English statements in the problem are *directly* translated into formulas; the solution is then obtained by plugging into equation (1).

English Phrase	Mathematical Translation
The probability of rain is 10%.	Pr(Rain) = 10%
The probability of cloudiness is 30%	Pr(Cloud) = 30%
The probability that it is cloudy in the morning given that it rains that day is 75%.	Pr(Cloudy | Rains)=75%
Calculate the probability of rain that day given that it is cloudy	Pr(Rain | Cloudy)
By (1), Pr(Rain|Cloud)=	Pr(Cloud|Rain)*Pr(Rain)/Pr(Cloud) = 75% x 10% / 30% = 25%

Table 1: Solution to the verbal problem presented in Section 2.1. Notice how the mathematics translation exactly mirrors the English formulation in this Version 1.

2.3 Two Alternate Formulations of the Bayes Theorem Verbal Problem: The Version I verbal problem in Section 2.2 - 2.3 allowed a word by word translation of the English phrases into mathematics. We present in this section 2 alternate verbal problems where the word order and real-world order are different. As we saw in the (a) and (b) examples of the Padua remediation example in Sections 1.1 and 1.2, such reversals of word order from real-world order has the potential to create confusion in certain readers.

Version 2: The probability of rain is 10%. The probability of cloudiness (in the morning) is 30%. Given that it rains on a particular day, the probability that it is cloudy in the morning is 75%. I wake up on a day I plan for a picnic and find it is cloudy. Given this cloudiness, calculate the probability of rain that day

Version 3: 10% of the time it rains but only 30% of the time is it cloudy. The percent of rainy days starting cloudy is 75%. Calculate the percent of cloudy days on which it ends up raining.

As indicated above, the relationship between version 1 and version 2 is identical to the relationship between the (a) and (b) sentences in our study of remedial reading. Only word order changes, but this is enough to confuse a specific cohort of students.

Version 3 does not resemble version 1 at all. That is, there is no rearrangement of words leading to it. This instructor's

experience with teaching Bayes Theorem is that i) teaching the formula (1) with illustration and ii) then testing using problems like Version 3 is sufficient to confuse many good students into doing poorly.

However, one can approach Version 3 using the technique of textual organization structure; that is, one can teach the signal words and overall structure of Version 3 thereby enabling students to do well on any similarly worded problem.

3. IMPLICATIONS FOR TEACHING AND EQUITY

The examples covered so far, while introductory, are sufficient to address two important issues.

3.1 Teaching Obligations: What are the obligations of the mathematics instructor? Consider, by way of example, the instructor of Bayes' Theorem. Is the mathematics instructor only obligated to teach mathematical content? That is, the Bayes' formula, its meaning and illustration? Does the instructor then have the right on an examination to expose students to verbal problems such as Version 3 which they have never seen? Can the instructor defend him/herself by saying, "I am assessing whether the students can independently think?"

Or, does the mathematics instructor have a dual obligation to teach both the underlying mathematics as well as the textual organizational structure of a variety of reading passages? If these are the dual obligations of the instructor, what resources are available to assist instructors who wish to fulfill their obligations?

3.2 The Author's Practices: This author believes his obligation is dual; instruction in the mathematics' formula must be thoroughly presented; additionally, a wide variety of textual organizational structures must be taught.

It is in fact the author's practice to spend minimal class time on formulas, telling students, "You don't need an instructor to teach you how to plug in formulas." The instructor then spends the remainder (that is, most) of class time reviewing as many verbal-problem, textual, organizational structures as the instructor can find. Interestingly, there is no resource providing these problem varieties. Rather, the instructor (me!) has to carefully review many textbooks and identify distinct problem templates each one with its own textual organizational structure.

The instructor clarifies to the class, "On examinations there will be no plug-in problems, that is, problems whose solution can be obtained by a formula plug-in. Examinations will consist exclusively of verbal problems. Every distinct problem type presented in class will occur on the examination."

It follows that the students are being assessed on their knowledge of a wide variety of problem templates; they are being assessed whether they command at their fingertips the textual organizational structure cues and signals of a diverse portfolio of problems. Their critical thinking consists of their flexibility and agility in solving multiple problems and the ability to recognize and process each one quickly.

3.3 Equity: In this article we approach equity through the provision of signal words also known as cues, clues, and keywords as well as textual organizational structures. A person taught to recognize the high-level textual organizational structure and to pay attention to signal words - words (or word phrases) like *in contrast, however, but, on the other hand, therefore, as a result, so that, in order to, because, for example, also, first-second-third* - can achieve basic reading comprehension of narrative passages. (A good comprehensive list is found in Table 1 of [17]) As seen in the reading remediation example, presented in Section 1, use of signal words, particularly when coupled with graphic organizers, and asking questions (e.g. *what happened first*? *what happened afterwards?*) have immediate equalizing effect on learners [3].

4. BIBLICAL EXEGESIS, EXAMPLE #1

In Sections 1 and 2 respectively we saw that textual organizational structure is an important prerequisite for reading comprehension in the respective fields of reading and mathematics verbal problems. In this and the next section, we apply this method to biblical exegesis. Two modest illustrative examples are presented, one in this Section 4 and one in the next section.

4.1 A Sample Passage. In a famous passage, (Exodus 3), God, the Deity of the Jewish people, reveals himself to Moses, and requests Moses to free the Jews from their slavery in Egypt ruled by the Egyptian King Pharoh. Moses responds (Exodus 3:11) with the following verse:

> *Moses said to God: Who am I that I should go to Pharoh and that I should take the Jews out of Egypt.*

Rashi, a biblical commentator elaborates on Moses' response:

> Who am I that I should negotiate with kings (like Pharoh)? And even if I am so important, what merit do the Jews have that they should be worthy of a miracle and I should get them out of Egypt? [10]

4.2 Relevance vs. Naturality: Before continuing, we note the peculiarity that because the Bible is a moral code and moral book, almost anything a commentator says has *relevance*. This creates a tricky situation. The issue before us in analyzing a commentary should never be, "Is this relevant and meaningful?" It shouldn't be that question, because almost anything connected with the bible is relevant and meaningful. Rather, the question to be raised is, "Is the comment intrinsic to the text?" "Does a person reading the text, naturally and effortlessly arrive at such a comment?"

4.3 Bulleting effects To answer this question on the naturality of the Rashi comment, we use the primary reading technique advocated in this article, the technique of high-level organizational structure. In Section 1.3 we presented *collection* as one of the five types of narrative organizational structure. *Collections* in turn are indicated by a variety of cues including for example *bullets.* A *bulleted list* is simply the author's way of indicating that these bullets form a *collection* of reasons, comments, or attributes on a particular item being discussed.

But unlike Modern English, there are no physical bullets in the bible. In Modern English notation, an author can use a collection of bullets, typically filled in circles, to indicate a bulleted list. The biblical Author did not have bullets available. Instead, the biblical Author used repeating keywords as a substitute for bullets. Using this idea we rewrite the biblical passage above:

Moses said to God: Who am I that I should go to Pharoh and that I should take the Jews out of Egypt.

The relative pronoun, *that,* has been underlined. It is repeated by the biblical Author, not for purposes of meaning but for purposes of creating a bullet-like effect. In effect the passage could be formatted as follows

Moses said to God: Who am I

- *that I should go to Pharoh and*
- *that I should take the Jews out of Egypt.*

This is the required high-level textual organizational structure. The repeating keyword *that* indicates a *collection* textual structure which in modern English would be indicated by bullets. To *understand* the collection the reader must seek significance in each bulleted item.

Using the above analysis of the biblical text we can re-read the Rashi comment:

> (That #1) Who am I that I should negotiate with kings (like **Pharoh.**)
> (That #2) And even if I am so important, what merit do the **Jews** have that they should be worthy of a miracle and I should get them out of Egypt.

Rashi's basic comment is that there is a collection of bullets, as indicated in the biblical text with the signal word, *that.* One bullet refers to Pharoh and one bullet refers to the Jews. In other words, Rashi sees Moses as making a *collection* of protests one dealing with his inability to address kings, and the other with his expected lack of success with the Jewish people.

It is true, that Rashi injects his own colors into these comments. The bullet about Pharoh is formulated in terms of *Moses' importance to negotiate;* the bullet about the Jewish people is formulated in terms of merit and miracles. These personal colorings can slightly obscure the main point which is that Moses is making a *collection* of two protests.

In this case, the textual organizational structure was able to uncover the cues and signals and assist us in decoding the Rashi comment. It enabled us to see the main part of the Rashi comment as well as its particular colors.

5. BIBLICAL EXEGESIS EXAMPLE #2

In Section 4, we presented a biblical example using the textual organizer of *collection.* In this section we present an example using the textual organizer of one form of *compare and contrast,* the idea of *climax*, of building a theme up step by step.

It turns out that the discovery of this particular textual organizational structure has an interesting historical journey which we present below as needed background. The background is brought to show just how important textual organization is. In fact, the climactic aspect of textual organizational was overlooked for centuries leading to misreadings of the biblical text.

5.1 Parallel Passages: We begin our journey with the idea of *parallel passages* [12] The Bible is filled with many parallel passages. A parallel passage is a passage where a basic idea is repeated. The following example (Ps145:1) is illustrative

> I will bless *you* **every day**
> I will praise *your name* **forever.**

This passage consists of two verse halves. But each half *says the same thing in different words.* Using underlined, italics, and bold we have identified the three sources of repetition: i) bless-praise, ii) you - your name; iii) every day - forever.

5.2 Initial attempts - poetry: The initial attempts at understanding biblical parallelism (over a millennium ago) was that it is a poetic form. Hence, biblical scholars treated these passages the same way poetry is treated. The medieval understanding of poetry came from Grecian poetry. Hence initial attempts, over several centuries, of understanding these parallel passages, employed tools such as rhyme and meter the tools by which Grecian poetry are analyzed.

Sometimes the text did not exactly behave as expected! Perhaps a rhyme was off; perhaps meter was off. Since the readers perceived the textual parallel passages as being organized under the textual organizer of poetry, this naturally led to proposed emendations of the text.

5.3 Resurrection of Parallel passages: This continued until Robert Lowth in the mid-eighteenth century rediscovered what parallelism really meant. Lowth agreed that parallelism was indeed a sign of poetry; but Lowth argued that parallelism represented biblical poetry in contrast to Grecian poetry. Grecian poetry was based on rhyme and meter. Contrastively, biblical poetry was based on parallelism and parallelism in turn, according to Lowth, indicated *repetition with an element of addition,* or *repetition with an element of climax.*

This can be illustrated using the example presented in Section 5.1. The first half of the verse states that the Psalmist will *bless God every day.* The 2nd half, while accepting the first half, goes beyond it and adds something: *every day and forever.* Alternatively, it takes *blessing* which is a two-way relationship between the Psalmist and God and goes a step beyond to a possible three-way relationships where the Psalmist *praises* God to others. There are many ways to explain the extra increase and climax. The important point, according to Lowth, is that parallel passages should be understood as a separate form of poetry, biblical poetry, in which ideas are not merely repeated, but added to and developed.

5.4 Law vs. Poetry: For our 2nd example of a biblical text and Rashi comment we will use a parallel passage from the Decalogue, the ten commandments. This however requires clarification. The Decalogue is a *legal* passage containing the broad categories of Divine law obligatory on all Jews. It is not a poetic passage. Why then should it have any parallel passages?

The answer to this is simple but fundamental to understanding biblical passages. It is not the case that biblical poetry consists of parallel passages while biblical law consists of non-parallel passages. Rather both poetic and legal passages contain parallel passages. The difference between biblical poetry and biblical law is the *degree* of parallel passages. A poetry passage may have a significant majority of passages parallel while a legal passage may have a small but significant minority of passages parallel.

In other words, parallelism is a tool by which to couple *repetition* with *addition and climax.* This tool can be used either in poetic or legal passages. In a highly poetic passages many of

the texts will be parallel. In a legal passage, a few will be parallel.

The reason both legal and poetic passages use parallelism is because parallelism is a textual organizational structure that conveys certain types of meaning and this meaning and textual organization is of use in both poetic and legal passages.

5.5 Example #2: The Decalogue, the Revelation of God's will about laws that the Jewish people, just emancipated from Egypt, must follow, contains the following parallel passage (Ex20-03) prohibiting idolatry.

> *Do not have (possess) other gods in My Presence*
> *Do not make (manufacture) for yourself idols*

Rashi commenting on the parallel passage states as follows:

> Why does it say, "Do not have". Because it states [in the next clause] "do not make." Thus I have a prohibition on manufacturing (making). But how do I know that something already made and manufactured should not be kept (possessed)? Therefore the text says, "Do not have."

We already are aware that Rashi can inject his own color into biblical readings. To understand this Rashi comment we look at the overall textual organizational structure. This structure is parallelism. We know from the previous sections, that parallel structure indicates repetition with something extra added. This suggests the following climactic repetition

- Do not own idols
- Furthermore, besides not owning them, do not even temporarily produce (make) them to achieve profit (from their sales).

This interpretation is consistent with the Rashi comment which although phrasing itself in colorful manner, prohibits manufacturing (making) and retention (possession). As already indicated, there are often numerous methods to indicate a climactic parallelism. The method we have chosen - *ownership - production* - is rather basic and overlaps with many other interpretations.

6. MORE MATHEMATICS VERBAL PROBLEMS

In this paper, we have reviewed examples from reading, mathematics, and biblical exegesis. We close this paper with one more mathematical example, a linear algebra verbal mathematics problem in two variables [11].

6.1 The Problem Statement: *Amy purchases 4 peanut bags and one quart of orange juice for a total of $6. Bonnie purchases 1 peanut bag and four quarts of orange juice for a total of $9. How much does one peanut bag and one quart of orange juice each cost?*

We will approach this problem using the fundamental technique of textual organizational structure employed throughout this article. The textual organizational structure applicable to this problem is *verbalization of algebraic relationships.*

To properly understand such verbal problems certain signal words, also known as cues, clues, and keywords, must be identified; these signal words in turn will indicate key mathematical operations. We rewrite the paragraph from this perspective

> Amy purchases 4 peanut bags and one quart of orange juice for a total of $6. Bonnie purchases 1 peanut bag and four quarts of orange juice for a total of $9. How much does one peanut bag and one quart of orange juice each cost?

In this case the underlined word *and* is the verbalization of the mathematical operation of *addition;* the underlined phrase for a total of is the verbalization of the mathematical concept of *equality.*

Another key concept in verbal mathematical problems are the unknowns. Again we re-cite the passage, italicizing the unknowns

> Amy purchases 4 *peanut bags* and one *quart of orange juice* for a total of $6. Bonnie purchases 1 *peanut bag* and four *quarts of orange juice* for a total of $9. How much does one *peanut bag* and one *quart of orange juice* each cost?

As can be seen the cost of a *peanut bag* and a *quart of orange juice* are the unknown quantities. We should add that the various numbers in the problem *4 peanut bags,1 quart of orange juice*, correspond to multipliers of these unknowns.

6.2 Tabular Summary: Table 2, compactly summarizes the textual organizational structure, a *verbalization of an algebraic set of equations,* as well as highlighting the various keywords.

Notice, characteristics of the author's approach, (Section 3.2), that the final answer for *P* and *Q* are not given. According to the author, the hard part of the problem is not solving a system of two equations in two unknowns, something that can be done by computer assisted software. Rather, the hard part of the problem is the reading comprehensions of the problem text.

English	Mathematics
Amy purchases	
4 peanut bags	4P
And	+
1 quart of orange juice	1Q
for a total of	=
$6	6
Bonnie purchases	
1 peanut bag	1P
And	+
4 quarts of orange juice	4Q
for a total of	=
$9	$9
How much does	Solve for
1 peanut bag	P
and 1 quart of orange juice cost	Q

Table 2:Verbal modeling of a purchase problem with the two equations 4P+1Q=6, 1P+4Q=9. The table should be read both vertically (English, Math) and horizontally (English-Math correspondence)

7. CONCLUSION

This paper has explored one technique, textual organizational structure and shown it simultaneously useful for dealing with reading problems in ordinary reading, in mathematics, and in

biblical exegesis. The technique consists of being aware of the high-level organizational structure of a passage. Throughout the article, several structures have been studied including, problem/solution, antecedent-precedent, collection, cause-effect, comparison (climax), and verbalization of the abstract. Throughout the article there has also been emphasis on looking for verbal cues and signal words We have also discussed implications of this approach for teaching obligations and equity. We believe these ideas will prove useful in a wide variety of other contexts.

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