An Educational Problem-Solving Strategy Promoting Team-work and Interdisciplinary Assessment through Mathematical Conceptual Comprehension

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Abstract

Business presents challenges as persons from various places and disciplines must collaborate to produce a successful outcome. What each person brings to the workplace is unique, yet experiences gained throughout adolescence and adulthood should better prepare the individual for working within the confines of the issues through application of academic preparation. Consider strategies for effective problem-solving (Zwilling, 2011), which are not unlike those which are utilized in doing school-work, such as through addressing word problems. For example, to note just a few…"Take the time to define the problem clearly"; "Iteratively question the cause of the problem"; "Identify multiple possible solutions, followed by "Prioritize [a] potential solution". The use of word problems to enhance the interdisciplinary experience also provides an assessment tool and a model for ways to engage teams in problem-solving. Communication skills that are necessary for success in the workplace begin well before the persons become adults. This article will strive to introduce the reader to ways that schools may continue to, or begin to become more conscientious in preparing youth for future success.

Keywords: interdisciplinary; assessment; literacy; problem-solving; adolescents

Introduction

Interdisciplinary teaching and learning is considered a viable approach to introducing students to concepts and material that spans the curriculum. It is a way to introduce and demonstrate relationships that are relevant to a student's life, by showing the connections as being natural, rather than segmented into disciplines and content area domains. (Marzano, 1991; Jacobs, 1989; Tompkins, 1991) In other words, when talking about the weather, if the topic of geography is introduced – are we talking Science or Social Studies? When speaking of the economy, or gross national product (GNP), is it social studies or mathematics? When discussing the perils of navigating the sea, in search of Moby Dick, who may have been greater in length than the boat – is it literature, science, mathematics, health, or all of the above? Whatever the content demands, the language arts – listening, speaking, reading, and ideally, writing, or some combination thereof, will be involved. In order to 'navigate' the content – one must engage the necessary processes.

One aspect of our current curricular trends is that often the content and the processes are confused. Reading, writing, speaking, listening, calculating, comparing, analyzing, and comprehending are processes. The result of the process while engaged in learning material or content is the understanding of the content.(Pearson & Raphael, 1999). Through the appropriate process, the content is manipulated by the learner to 'make meaning' based on prior and present experience, and the skills applied to integrate the content into existent structures within the learner's thinking. The nationally adopted Common Core State Standards (2010) are reflective of integrating the language arts with content area standards, particularly in grades 6 – 12. Professional development, however, will be necessary to enforce the integration of the standards effectively. The Common Core Standards are directly aligned to workplace skills and career goals and objectives. Preparation begins throughout elementary, middle, high school and college.

Often, teachers expert in one area are reluctant to tread into another disciplinary area. The science teacher may be unwilling to discuss the effect of the splitting of the atom on the socio-political times before, during, and after the discovery.

The social studies teacher, while discussing government, may not want to have students calculate the taxes, including percentages, based on legislation introduced to alleviate poverty, for example. The sense of 'territoriality' or lack of expertise, or any number of things may inhibit the content area teachers from 'crossing the line'. But this is not an issue unique to middle and secondary levels.

Teachers in the elementary level, though responsible for teaching all disciplines, often segment the day into content areas, without thought of relating material across disciplines. Moreover, the 'reading' and 'mathematics' portions of the day are traditionally placed at strategic times to capture the student's most optimum attentiveness, and the skills are taught in isolation through the use of proscribed material, designated into skill-sets and vocabulary lessons, or workbook pages of mathematical operations.

Over the years, though publishers have demonstrated increasingly more sensitivity to introducing expository text, and literature into the basal readers, often teachers abandon incorporating skills any other time of the day. In fact, even some mathematics textbooks are now including more text into the area of mathematics, with literacy prompts. Technical vocabulary, for example, is an important entity, and is an integral part of comprehension of expository text, and literacy in any area (Chung, Nation, 2003). Literacy embraces many facets of a learner's daily interaction with content. One of the most obvious needs in this regard is in the area of word problems. Without even viewing the literature, one's own experience might suggest that word problems are either hated or loved by the learner.

The Challenge and Concrete Examples

For those inclined tofavor mathematics, the problem is that, as one student railed, "There are too many words!" For those who favor reading, the challenge is in weeding out the calculations, and then understanding what to do with what is there. Word problems, however, may present the most interdisciplinary task that students may do at any given time. Often the material is based on science, social studies, health, art, music, physical education, literature, or some other content-based area. Subsequently, word problems may also provide an opportunity as one of the most multi-dimensional assessment tools that the teacher can employ.

For example, based on Bloom's taxonomy (Bloom, 1956), word problems embrace every level of cognition – remembering, understanding, applying, analyzing, evaluating, and creating. (The terms used to be 'knowledge', 'comprehension', 'application', 'analysis', 'synthesis', and 'evaluation'). These levels of cognition may be better met through attending to reading skills needed to complete the task.

First, the learner must recognize the main idea, including it's' relationship to the question. Then, the supporting details should be identified. This would be at the 'remembering' level of cognition. Pertinent information should be discussed, as well as any inferences that must be derived from the material. The learner will have moved into the 'understanding' phase of the taxonomy. Then the learner must be able to interact with the text in a meaningful way, to determine the writer's intent. This would entail applying the information to determine what the question is asking. The writer's intent should reveal the necessary operations needed to complete the task. Analyzing, at this point, is taking place. The stage of evaluation is engaged as the learner does the necessary operations, based on what is in the text, to ascertain the relationship of the operations to resolving the question. Finally, the learner will 'create' the response, meeting the demands of the task. The learner may also be motivated to create another word problem, based on the same material, or a similar circumstance.

In considering the taxonomy, and the integration of literacy skills in the solution of a word problem, an example of the process may be as follows:

"Last year, Conner paid 15% of his earnings in federal taxes. He paid $3000.00. Jose also paid 15% of his earnings in federal taxes, but he paid $3600.00. How much more did Jose earn than Conner?"(p.160)

What is the main idea? *Connor and Jose both paid federal taxes*.

What are the supporting details? *Both paid 15%. Connor paid $3000 and Jose paid $3600.00*

What are the inferences, or issues to be resolved? *Jose made more money than Connor. There is a difference between 15% of Connor's total, and 15% of Jose's total paid, which needs to be found.*

What applications or operations must be used to solve the problem? *Multiplication of the percentages, followed by subtraction of the differences -- .15x3000 vs. .15x3600, or perhaps dividing the percentages, and multiplying the total by 15%, or subtracting the totals and multiplying by 15%.*

The point is that, at this point the text is understood, and the math becomes the focus. Without going through the first few steps, the actual problem may not be understood. The solution may involve conceptual understanding of taxes (social studies), as well. The assumption is that the learner knows what taxes entail, and how they are generated.

It would be more comprehensive to also consider that all learners approach tasks differently. As laterality studies are considered, as well as work done in the area of multiple intelligences (Gardner, 2006), one might think of the learner as being more 'verbal-sequential' in the comfort of approaching a task, or more visual-spatial. The visual-spatial learner may see the relationship(s) more clearly from just focusing on the mathematics that may need to be involved, though the verbal-sequential learner may be more dependent upon the text in finding the result.
The 'kinesthetic' learner, though restricted by the setting, may have to, at least, 'walk themselves through' the material to come to a reasonable approach for solving the word problem. It also would be helpful, perhaps, to develop a semantic organizer of the word problem to aid those who will need to 'unpack' the text, in order to identify the cogent parts of the puzzle. Of course, the text in the example above did not require a great deal of 'unpacking'. Let us consider a more detailed word problem:

"Blood type is determined partly by which antigens a red blood cell has. An antigen is a protein on the surface of a red blood cell. Type A contains the A antigen. Type B contains the B antigen. Type AB contains both A and B antigens. Type O does not have any antigens. A hospital has 25 patients with the A antigen, 17 with the B antigen, 10 with the A and B antigens, and 30 without A or B antigens. How many patients are represented by the data?

- How can a Venn diagram help you solve the problem?
- What strategies can you use to complete the Venn diagram? (p.219)

What is the main idea? *There are a number of patients in a hospital with various blood types.*
What are the supporting details? *25 patients have A, 17 patients have B, 10 have AB, and 30 have type O.*
What is the inference or discussion, if any? *A Venn diagram can be used to show the 'breakdown' of the patient's by blood-type.*
What operations or calculations can be used to solve the problem? *Addition, then categorization, or categorization, then addition*
How will the results be best represented? *By blood type and totals in the appropriate circles*

Though the calculations seem relatively simple, the text included a great deal of information that may not necessarily appear pertinent to the application of the operations. The learner at first glance, could feel compelled to understand the definition of 'antigens', as well as the distinctions between the antigens. The antigen, as noted by the letter designations, was information that was not directly related to the answer, in terms of finding the total. Going through the exercise of extracting the main idea and supporting details relevant to the task may have aided the learner in solving the word problem without getting lost in the text. The information, however, was interesting, and indicative of an interdisciplinary approach to teaching and learning, in that science, health, and math were combined in the word problem. Vocabulary may have also been explored more fully, as the Latin prefix and root of the word *antigens* could have been discussed, either then or at an earlier or later time during the lesson.

In fact, in an 'interdisciplinary' world, the lessons being offered in social studies, science, health, English, art, music, and any other subject areas would be coordinated to reflect a more thematic approach to meeting the standards and course requirements. There is work and planning involved, but the concept of the one-room classroom, with many collaborative professionals working to provide relevant instructional units will better serve the whole learner than segmenting the thinking mind into discrete units of information – seemingly unrelated in presentation, and divided into minutes and blocks of time, rather than interest, discussion, and following the 'threads' of thought. Word problems represent a small foray into combining content areas, and can be used in all disciplines to highlight relationships between curriculum content and processes.

Strategies for Team-Building and Competition

Business.com touts methods of successful problem solving in business, including but not limited to things such as "breaking a problem down into smaller, more manageable parts"; examining problems from more than one perspective; understanding how more than one factor can interact with others; and identifying factors – internal and external – that contribute to a problem. All of these factors and more can be aligned with those skills introduced and reinforced through solving word problems. In addition, the problem-solving need not be done in isolation.

An informal observation of how attention to word problems can change the culture of a school is evident in the following example. In two different elementary schools, and one middle school situation, word problems, written by each classroom, were read to the whole school the first thing in the morning, at least once or twice a week. During the day, the problem was discussed by the class and the responses were sent to the office. At the end of the day the class whose word problem was announced was given credit, and the class who sent down the first correct answer was also given recognition. In each classroom, teachers were instructed to use the word problem to enhance comprehension skills as well as to use for the purpose of mathematical calculation. Also, in constructing the word problems, on each level, attention was given to the language, the information included, and the expected result. In each school, student achievement on the standardized tests was higher, not only as relates to word problems, but also in comprehension as a whole.

This 'informal' research can be replicated without penalty, for any who want to even demystify the intimidation that word problems may create for learners. There were two different levels of problems – in terms of the math, and vocabulary used in the word problems, divided into Kindergarten to grade two, and grades three through five in one school (K-5). In the other school, which was K-8, the grade divisions were K-2, 3-5, and 6 – 8. In middle, junior high or high school, the interdisciplinary nature of introducing the word problem school-wide could be a unifying activity.

The word problems written by the classes were, as much as possible, based on content that was being taught and learned in each grade level, based on the standards. The results of the competition were posted on a bulletin board just outside of the office, and students were anxious to see the results in a bar graph chart updated weekly.
The ability to solve and to write word problems assesses students on many different levels, including thinking skills, mathematical calculations, comprehension, and any other content material that is included in the text, in terms of information. Working through the word problems in a class discussion enhances speaking, listening, and conceptual development. The word problem is a combination of mathematical sentences comprised of symbols and words or lexicons. The symbols are numerals and operational messages. The words, in sentences and phrases, add depth, in terms of placing the mathematical sentences into a context that derives meaning within a conceptual framework. Solving the word problem involves an assessment of mastery in both the text comprehension and the understanding of the mathematical operation.

When reading/comprehension skills are applied to addressing mathematical operations, employing the taxonomy of cognitive processes, the learner may experience and demonstrate a multi-dimensional application of skills. The Common Core State Standards (2010) indicate many opportunities for students to demonstrate understanding of simple and complex concepts through the use and articulation of finding meaning. Many of the skills that will be assessed in terms of addressing word problems will be found in the standards in K-5, as well as more specifically in the technical application of the standards in grades 6 through 12. Word problems are not new. To even the octogenarians among us, past students and educators both muddled through them to please the teacher, and to pass tests. There is now an opportunity to apply what we know as scientific application of theorems in educational pedagogy to understand why we are doing what we are doing. Further research can determine whether we are progressing when utilizing the benefits of word problems to create an interdisciplinary approach to teaching and learning. Curriculum, assessment, and instruction are a triangle, or circle worth navigating in introducing a balanced approach to teaching and learning. There are several recommended strategies to encourage the professional to use the information to aid student growth and development. These strategies have been used for different populations over several years:

1. Encourage students in each content area class to write word problems associated with the material in the lesson. Lessons may be specific on how to construct a word problem, i.e. the elements and the expected outcomes. (Professional development would be necessary to support teachers in this activity).
2. Have students create word problems weekly for sharing or distribution among classmates – the word problems may be analyzed and critiqued if one chooses not to 'work out' the problem. Or, the responses will be returned to the student solved.
3. Initiate a school-wide competition – posting results in a common area for students to view…feature the "winning" word problems as voted on by the content area classes.

The strategies are not only recommended for academic reason, but also to create 'community' and to provide a comfort level within the teaching-learning community to problem-solve in ways that will mirror that which occurs in the workplace.

Problem-solving, based on effective communication is key to the resolution of global issues and future success of a shared global vision, supported by youth who have been invited to explore interdisciplinary real-life situations.

Conclusion

Many are now chanting the mantra of 'relevancy' for education. Throughout the curriculum, there are opportunities to link standards with real-life situations. Literacy development through word problems affords the learner the benefit of interdisciplinary approaches to viewing problem-solving, as well as the vocabulary and conceptual development that accompanies higher order thinking skills as applied to the discussion and outcomes. The same skills reinforced through these strategies are found to be valuable in the workplace as well. Successful business practices are those that require the same diligence and attention to detail, as well as the organized methodologies that are a part of effective problem-solving throughout the school years. The Standards are most effectively integrated when those in Education have an opportunity to view the bigger picture, related to all aspects of literacy. Attention to problem-solving, linked to a focus on comprehension, across the content areas for each school year may more certainly develop within the learner a comfort level with the strategies also needed for success in the world of Business and the global economy.

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More to Explore

UTube**:** Dr. P. David Pearson talks about Seeds of Science/Roots of Reading. September 19, 2011.

UTubeDisciplinary Literacy – Teaching Students Important Skills, July 30,2010, (with Jacquey Barber, co-principal investigator for Seeds/Roots and associate director of the Lawrence Hall of Science.

Introduction to the Improving Mathematical Problem Solving in Grades 4 Through 8 Practice Guide. . . 6. Recommendation 1.Â Problem solving involves reasoning and analy-sis, argument construction, and the develop-ment of innovative strategies. These abilities are used not only in advanced mathematics topicsâ€”such as algebra, geometry and calcu-lusâ€”but also throughout the entire mathemat-ics curriculum beginning in kindergarten, as well as in subjects such as science. Moreover, these skills have a direct impact on studentsâ€™ achievement scores, as many state and national standardized assessments and college entrance exams include problem solving.9. Problem solving is an important competency for learners. The importance of this competence contained in the curriculum of education in Indonesia. Math problems have difficulty level that are high enough. The more complex concepts involved in a problem, the higher difficult level of the problem. Thus, solving mathematical problems require the ability to associate many concepts into a united concept to bring up as a key concept. The key concept results an appropriate problem solution.Â The result describes the importance steps in solving mathematical problems based on conceptual thinking. Those steps are (1) describing problems, (2) associating problems, (3) determining key concepts, and (4) formulating solutions. Discover the world's research. High-quality mathematics assessment must focus on the interaction of assessment with learning and teaching. This fundamental concept is embodied in the second educational principle of mathematics assessment. The learning principle. Assessment should enhance mathematics learning and support good instructional practice. This principle has important implications for the nature of assessment. Primary among them is that assessment should be seen as an integral part of teaching and learning rather than as the culmination of the process.1 As an integral part, assessment provides an opportunity for te Keywords comprehension strategy instruction, English learners, mathematics education, problem solving, mathematics learning disability, teacher professional development and preparation. A large and increasing proportion of students in U.S. schools come from a home in which a language other than English is spoken.Â language is most challenging due to (a) they are increasingly included in general educa-tion classrooms where the demands to prob-lem solve and learn from mathematics text are substantial and (b) they are unlikely to receive inadequate mathematics instruction such as lack of exposure to comprehension strategies to improve problem-solving effi-ciency (e.g., Martiniello, 2008, 2009; National Mathematics Advisory Panel, 2008). D. Heuristic and Strategies for Mathematics Problem Solving. E. Problem-Based Learning for Joyful Learning in Primary Mathematics Instruction. F. Some Ideas of Problem-Based Learning.Â 1. Problem solving in school mathematics curricula, 2. Classification of mathematical problems, 3. Heuristics and strategies for mathematics problem solving, 4. Problem-based learning for joyful learning in primary mathematics instruction, and 5. Some ideas of problem-based learning. The objective of this module is to provide some knowledge and skills that related to the mathematics problem solving and problem-based learning in primary mathematics instruction.

Approaching mathematics through problem solving can create a context which simulates real life and therefore justifies the mathematics rather than treating it as an end in itself.Â Problem solving is, however, more than a vehicle for teaching and reinforcing mathematical knowledge and helping to meet everyday challenges. It is also a skill which can enhance logical reasoning. Individuals can no longer function optimally in society by just knowing the rules to follow to obtain a correct answer.Â Although mathematical problems have traditionally been a part of the mathematics curriculum, it has been only comparatively recently that problem solving has come to be regarded as an important medium for teaching and learning mathematics (Stanic and Kilpatrick, 1989). Disabilities Through Mathematical. Problem Solving. Fred Spooner1, Alicia Saunders1, Jenny Root2, and Chelsi Brosh1. Abstract. There is a need to teach the pivotal skill of mathematical problem solving to students with severe disabilities, moving beyond basic skills like computation to higher level thinking skills. Problem solving is emphasized. as a Standard for Mathematical Practice in the Common Core State Standards across grade levels. This. article describes a conceptual model for teaching mathematical problem solving to students with severe. disabilities based on research from a multiyea...Â Problem-solving experiences in school settings are typically structured in the format of story or word. Introduction to the Improving Mathematical Problem Solving in Grades 4 Through 8 Practice Guide. . . 6. Recommendation 1.Â Problem solving involves reasoning and analy-sis, argument construction, and the develop-ment of innovative strategies. These abilities are used not only in advanced mathematics topicsâ€”such as algebra, geometry and calcu-lusâ€”but also throughout the entire mathemat-ics curriculum beginning in kindergarten, as well as in subjects such as science. Moreover, these skills have a direct impact on studentsâ€™ achievement scores, as many state and national standardized assessments and college entrance exams include problem solving.9.