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Problem Solving as Motivation in Mathematics: Just in Time Teaching

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Abstract: This paper uses case study methodology to describe a program of instruction at the secondary school level that utilized problems, preferably real world problems, to serve as motivation for students to acquire mathematical content. The problems focused on near transfer, with the goal of turning problems into exercises and routine tasks, through student-developed strategies, supported by teachers using a "just in time" teaching strategy. This program, implemented over 30 years ago, was unique and very advanced for the era. Elements of this program can be seen today in the philosophy espoused by the National Council of Teachers of Mathematics [1-2], the Ontario Ministry of Education [3], and the U.S. Common Core State Standards [4].

Key words: Problem solving, mathematics, motivation, case study.

This paper is dedicated to Joseph Stein (May 1, 1930—February 6, 2014), who was a Visionary, Leader, Teacher, Aeronautical Engineer, and Father.

1. Introduction

There are a number of different definitions of problem solving in the literature. Yunis and Ali [5] cite the definition of Mayer and Witrock (1996), that problem solving is a cognitive process directed at achieving a goal when no solution method is obvious to the problem solver. Cotic and Zuljan [6] identify a mathematical problem as having an initial undesired situation, a desired end situation, and an obstacle preventing the movement from the initial situation to the end situation. They go on to discuss that a situation can represent a problem for one person, but a routine task for another, depending on whether the person is familiar with the path or strategy to move from the initial situation to the end situation [6-7]. Schoenfeld (1992) has written extensively on problem solving in mathematics. He points out that "'problems' and 'problem solving' have had multiple and often contradictory meanings through the years—a fact that makes interpretation of the literature difficult" [7, p. 337]. He identifies the goals of problem solving activities in mathematics as: to train students to think creatively; to prepare students for problems competitions; to teach pre-service teachers heuristic strategies; to provide a new approach to remedial mathematics; for students to learn standard techniques, such as mathematical modeling [7, p. 337]. The case study described in this paper has, as its focus, the last of these, namely, for students to learn standard techniques, such as mathematical modeling. In the case, ancillary benefits include thinking critically and creatively, and some heuristics and approaches typical to mathematics, such as similar but simpler, counter example, make a diagram, look at special cases, and so on. Schoenfeld also points out that the spectrum of "problem solving" often includes routine exercises, means to a focused

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end, a skill to be taught, and, sometimes, problems that are closer to what he calls “mathematicians’ problems,” which are closest to the activities of mathematicians [7]. For the case in question, the goal of the program was for students to turn “problems” into “exercises,” using problems as a vehicle for students to acquire mathematical content, including knowledge and skills appropriate to their developmental levels, while, in addition, fostering and supporting student motivation to do mathematics. To do this, problems were used to “frame” the mathematical discourse [8]. The mathematical content that was the focus of the lesson was embedded in a problem situation that often was quite closed in nature, but might be open routed or open, depending on the topic and lesson goals.

2. Transfer

Martinez states “Transfer is so important that it arguably is the ultimate goal of education” [9, p. 111]. Similarly, Perkins and Salomon identify transfer as “integral to our expectations and aspirations for education” [10, p. 22]. They argue that knowledge and skills acquired in formal schooling is generally inert, and neither useful for nor available for transfer. In particular, studies have shown that transfer is more likely to occur in situations of near transfer, and much less likely to occur for far transfer [11]. Spiro and De Schryver discuss this problem by contrasting Well-Structured Domains and Ill-Structured Domains (ISDs) [12]. Well-structured domains are generally closer to (sometimes identical to) the contexts in which knowledge and skills are learned. They also tend to be more closely related temporally to the learning of these skills. Ill-structured domains lack most or all of these attributes. “Ill structured domains are characterized by being indeterminate, inexact, noncodifiable, nonalgorithmic, nonroutinizable, imperfectly predictable, nondecomposable into additive elements, and, in various ways, disorderly” [12, p. 107]. In addition, ISDs tend to also be temporally further into the future. Thus, although far transfer is identified as a major goal of formal education, there is little evidence that this type of transfer occurs. Barnett and Ceci point out that “Children ... transferred when they developed a deep, rather than surface, understanding” [11, p. 616]. Therefore, since transfer is central to learning, any theory of learning or teaching must address the need for deep learning. In this case study, problems were almost always embedded in well-structured domains, and the problem solving was intended to serve as motivation for students to engage in near transfer, applying the skills and knowledge learned during the problem solving to tasks that were similar to or related to the problem already addressed.

3. Scope

Paulo Freire, in a scathing indictment of the traditional education system, identifies problem solving as critical to moving education away from what he calls the “banking model,” where the teacher is the transmitter of knowledge, and the student is the passive, empty vessel to be filled [13]. Both Schoenfeld and Pimta, Tayruakham, and Nuangehalerm identify problem solving as the “heart of mathematics” [7, 14]. In practice problem solving in some form seems more common at the elementary levels, such as Fosnot and Dolk’s [15] *Young Mathematicians at Work*, or the work of Marian Small [16]. It has also become more prevalent in universities [12, 17]. Interestingly, it still appears to be less common in secondary schools. This case study discusses a program begun in a secondary school in 1978, and was a lighthouse program at the secondary level. While problem solving has become a major focus of mathematics teaching, this focus is not unanimous. For example, Kamaruddin and Amin, in an article entitled *Dilemma in Teaching Mathematics*, decry the current emphasis on problem solving, viewing it as devaluing mathematical content, and that the utility value of mathematics is short sighted, placing application above the beauty and aesthetic value of the subject [18].

More recent research has emphasized the multiple dimensions of problem solving.

The theoretical frameworks that explain the problem-solving (PS) process have gradually come to include cognitive, affective and contextual dimensions. Beliefs in mathematical problem solving have been studied primarily as regards two perspectives: their role in explaining success or failure in PS (Schoenfeld, 1985) and the affective dimension of PS (McLeod, 1994; McLeod & Adams, 1989). The current lines of research into PS include those focused on the role played by beliefs and affect and the interrelation between the use of knowledge, control, affects, beliefs and context [19, pp. 111-112].

One problem-solving model that integrates these dimensions is shown in Figure 1. This model specifies four major dimensions, content understanding, strategies, metacognition, and motivation, with sublevels for all except content understanding [5]. In the diagram, the levels and sublevels addressed by the program in the case study are highlighted. Note that some sublevels are addressed directly, and others are addressed indirectly, meaning that they were not the primary focus of the program, but were addressed by teachers during the problem-solving process.

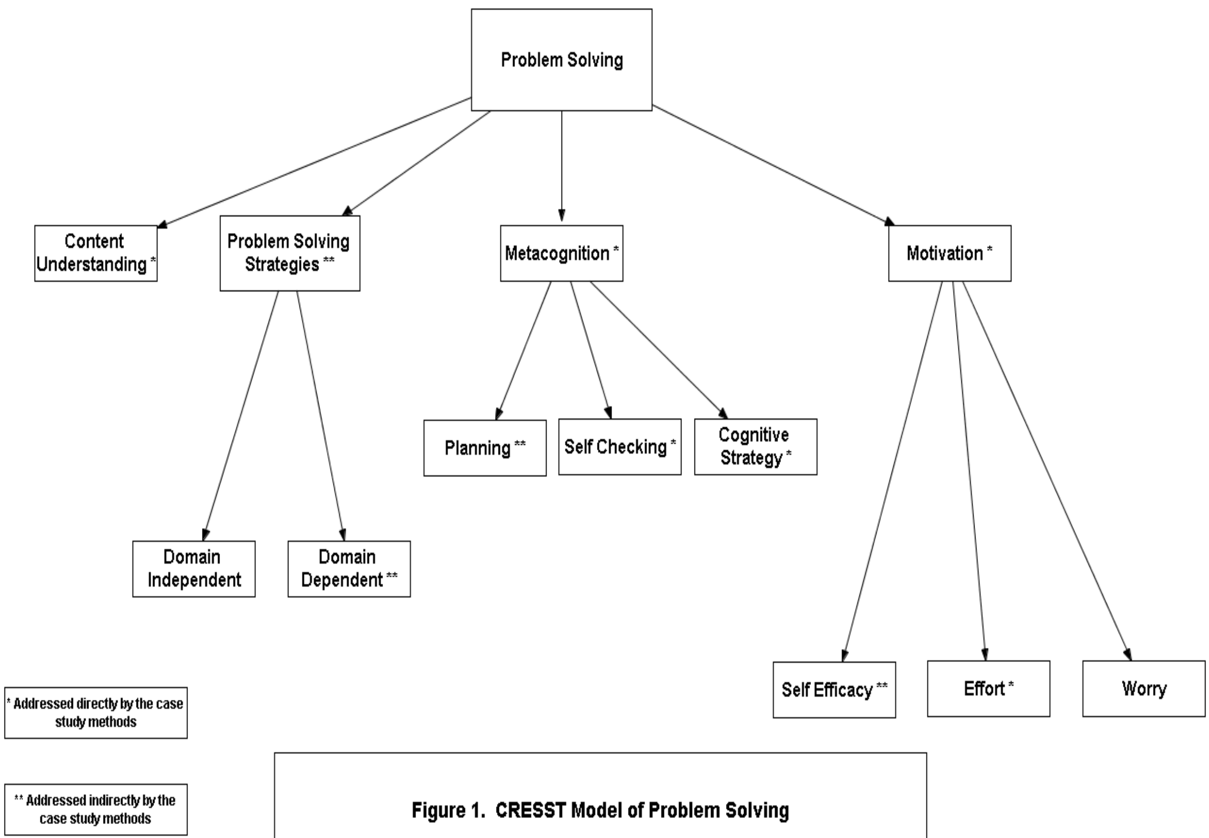

Figure 1. CRESST Model of Problem Solving

Adapted with permission from O'Neil, H.F., & Schacter, J. (1997) Test specifications for problem solving assessment, p.5

4. Real World

Lee identifies a number of ways that mathematics and problem solving are connected to the "real world." He enumerates simple analogies (e.g., relating temperature to negative numbers); classic "word problems;" analysis of real data; discussions of mathematics in society, such as misuse of statistics in the media; hands-on representations, such as physical models; and, mathematical modeling of real phenomena [20]. I take issue with the categorization of classic word problems as "real world." Even Lee's example (Two trains leave the station...) is an example of, at most, an exercise of an algorithm, dressed up in some verbiage. Word problems, as taught in most classrooms, have no connection to the real world. At best, they provide some practice at literary decoding. At worst, they confuse, demotivate, and perpetuate the myth that mathematics is difficult; that problem solving involves application of a known algorithm, once the "clues" in the wording are deciphered; that mathematics problems should be solvable in a few minutes, otherwise give up as unsolvable; that students of mathematics should maintain an ability attribution model, rather than an effort attribution model [9]. In this case study, real world problems had one or more of the following attributes: (a) students could use the mathematics immediately, for example, in their part time jobs, budgeting, or sports; (b) students could use the mathematics in another subject, in the near term, such as in science, geography, technical shops, family studies; (c) someone close to the student could or did use the math content, such as a family member, relative, adult acquaintance; (d) there were examples in the real world of people using the mathematics; and (e) the mathematics flowed from an investigation, experiment, or model in which the students were involved.

5. Motivation

Motivation is a key dimension for students doing mathematics. Like problem solving, there are multiple and sometimes contradictory definitions of motivation. Yunis and Ali describe motivation as a student's willingness, need, desire, and compulsion to participate in, and be successful in, the learning process [5]. Other researchers define motivation as an individual's desire to act in particular ways, or personal agency [21]. Motivation, therefore, involves students' willingness or desire to engage in their learning.

Numerous researchers have identified sublevels of motivation. Marzano and Kendall describe motivation as an amalgam of self-efficacy, task importance, and emotional response [22]. In Marzano's taxonomy, motivation is seen as residing in the self-system, which engages first in the learning process, with decisions on the importance of the task and engendering a positive emotional response to the task [22-23]. Walter and Hart describe sources of motivation as task interest, social environment, opportunity to discover, knowing why, using objects, and helping others [21]. Sungur examined the motivational links to task value, intrinsic goal orientation, self-efficacy, metacognitive strategy use, effort regulation, and learning beliefs [24]. Yunis and Ali identify self-efficacy, effort, and worry as dimensions of motivation [5] (see Figure 1). All of these descriptions have common elements, such as self-efficacy, and most include task interest, importance, or relevance. Thus, interesting tasks stimulate student motivation. Conversely, Hoffman and Spatariu describe the *motivational efficiency hypothesis*, that identifies positive motivational beliefs such as self-efficacy, personal goal orientation, intrinsic motivation, engagements, and metacognitive strategy use as all being related to more efficient problem solving [25]. Therefore, while task interest is related to motivation, so motivation is related to task efficiency.

This case study describes a program focused on task importance, as represented by relevant problems, with the goal of building student motivation as a vehicle to learning mathematics content. Byproducts of this approach include increased student self-efficacy, more positive attitudes towards mathematics as a problem solving tool, and support for effort as a major dimension in student achievement. Through the elements of this program, students became proficient in mathematical content, posed "What If" conjectures, and examined similarities and differences across a wide array of problems.

6. Case Study

This paper examines a holistic, single case study [26], with the unit of analysis the student body taught by members of a specific mathematics department during one school year. The case examines diachronic covariation [27] of student engagement, attitudes, and achievement across the first year of operation of a new secondary school.

The research question was:

How can problem solving be used to support and enhance student engagement, attitudes towards learning, and achievement?

Propositions:

(1) Teaching through a focus on real world problem solving will have a positive effect on student achievement;

(2) Teaching through a focus on real world problem solving will increase student engagement;

(3) Teaching through a focus on real world problem solving will have a positive impact on student attitudes towards learning mathematics.

The primary method of investigation was semi-structured interviews. As a participant-observer in this case, I conducted self-interviews consisting of three one hour sessions. To do this, I first developed questions on the major facets of the program. I then responded in writing to each of these questions. The third of these self-interviews was for clarification and elaboration, after investigating other sources of information. I conducted a three hour semi-structured interview with the former department head (now retired), probing his reasons for establishing the program, and any research he conducted before initiating the problem-solving focus. I scribed his responses to my questions and any elaborations he made during follow-up questions. To triangulate the data, I also conducted informal face-to-face interviews with two of the former teachers in the department, and interviewed a third former department member via email. Responses to these interviews were scribed, and follow-up questions ensured the accuracy of the scribing. Finally, I utilized artifacts that had been developed when the department head was nominated for a teaching award. These consisted of the nomination form plus three letters of support from teachers and former students, as well as a letter from the former principal of the school.

7. Background

In 1978, a new secondary school of approximately 900 students was opened in a suburban area in Ontario, Canada, in a city of 500,000. The city and the school were ethnically diverse, with Caucasian as the majority, but with significant minorities of South Asian, Black, Middle Eastern, and East Asian. The students were all transfers from other schools in the area, and many of them were unhappy to have been moved away from their friends and familiar surroundings. A large segment of the student population was bussed to the new building. The building was unfinished when the school year started, with no gymnasia, science labs, library, or technical shops. In addition, the student body was on an early 7:30 AM to 12:30 PM shift, to accommodate students from another new school, where construction was even further behind. Those students had the late shift, 12:30 PM to 5:30 PM. There was overlap with the two schools over the lunch hour, and numerous altercations between the two student bodies occurred. The school offered courses for mainly Grades 9 to 11, with a few Grade 12 classes. This was a common new school development model, where the school would mature as a grade was added each year.

The department head of the mathematics department was a former aeronautical engineer, who went into teaching when the jet aircraft on which he was working (Avro Arrow) was cancelled by the Canadian government. He had a very strong philosophy of mathematics as a tool, and that students needed to see the relevance of their learning through relating the content to the real world. The department head hand-picked a department who were in agreement with this philosophy and who agreed, as a condition of moving to the school, to reverse the traditional theory followed by application, into application followed by theory necessary to solve or move forward the real world problem. I was a member of this department.

8. Structure of the Program

This program involved several elements: a class problem that began every class, just in time teaching, flexible groupings, extensive use of technology, and attention to metacognitive dimensions of learning. The class problem and just in time teaching were the centerpieces of the program.

9. Class Problem

Every class started with a problem. As far as possible, the problem would be based on real world concepts. The working definition of real world involved one or more of the conditions enumerated earlier.

(1) Students could use the mathematics immediately, for example, in their part time jobs, budgeting, or sports.

(2) Students could use the mathematics in another subject, in the near term, such as in science, geography, technical shops, family studies.

(3) Someone close to the student could or did use the math content, such as a family member, relative, adult acquaintance.

(4) There were examples in the real world of people using the mathematics.

(5) The mathematics flowed from an investigation, experiment, or model in which the students were involved.

What was explicitly not accepted was the traditional "trust me, you'll use this later." The problem might be the focus of one class, or an overreaching problem might cover multiple classes, with each class dealing with a subproblem of the main problem. The class problem was explicitly designed to go beyond the students' current knowledge, or to use that knowledge in a new way. Student motivation to study the content was paramount to this program. Every class was designed to give the students an immediate reason to learn the mathematics content. Some examples of class problem topics are shown in Table 1. The problems ranged from closed problems, with a predictable problem solving route and a single answer, through open routed problems [16], with a single answer but multiple paths to the solution, and included some truly open problems, with multiple solution pathways and multiple possible answers.

10. Just In Time (JIT) Teaching

The second dimension of this program was Just In Time Teaching. The just in time concept comes from industry, where it was pioneered in North America by companies like Toyota and Dell Computers [28]. The just in time structure is based on providing customers with supplies "just in time," that is, exactly when the supplies are needed. Therefore, a Toyota car plant would keep very low levels of parts inventories, and their subsuppliers would provide parts very near to the time the Toyota plant needed them [28]. In this way, Toyota reduced their inventory carrying costs, as well as reducing their average ordering costs. In a study of McDonald's use of JIT, Atkinson points out "Whenever you can implement something that allows you to raise quality AND lower costs, you should definitely look into implementing that practice" (emphasis in original). Broyles, Belms, Franko, and Bergman [29] point out that partnerships are key to the success of JIT; "Possibly the single piece of JIT that has the most relevance to a study of supply chain management is the partnerships that are essential to making JIT truly work" (p. 1). They also point out that "Communication is king in a JIT rich supply chain" (p. 2).

In teaching, the JIT concept was modified to support the problem solving focus. For example, if a problem solution required knowledge of equation solving, and equation solving had not already been encountered by the students, a lesson or mini-lesson on equation solving would be taught. After practice and consolidation the students would return to the class problem. If equation solving was the only skill needed to complete the problem the students would then use the new skill to complete their solutions. If additional new skills or concepts were needed, another pause would occur while a lesson was taught on these additional skills. This process would continue until the class problem was completed. By using this structure it was always clear to the students why they were learning the mathematics content “just in time.” Some examples of class problems are listed in Table 1.

Table 1 A Sample of Content Topics and Related Class Problem Topics.

Topic of Study	Problem Focii
Venn diagrams	Earthquake epicentres; consumer attributes
Intersection of lines	Breakeven analysis; pursuit problems
Integers	Temperature, especially extremes; climate (geography)
Logarithms	Richter scales; pH; magnitudes of stars
Linear relations	Simple interest; comparing printing costs; density (science)
Bar graphs	Climate; population (geography)
Circle graphs	Net worth; budgeting
Exponential growth	Population; compound interest
Parabolas	Profit maximization; headlights; catenaries
Hyperbolas	LORAN navigation system; comets
Ellipses	Planetary orbits; satellite transfer ellipses
Perimeter, area, volume	Fence it, paint it, fill it up; design a garden, room, amusement park
Similar triangles	Inaccessible distances; shadows
Triangle trigonometry	Inaccessible heights; clinometers
Displacement, velocity, acceleration	Physics problems; experiments
Periodic functions	Radio waves; biorhythms; ferris wheels
Geometric sequences and series	Compound interest; annuities; chessboard problems
Arithmetic sequences and series	Simple interest; linear relations
Matrix operations	Power ratings of sports teams; Markov chains; communication networks; cryptography
Matrix equations	Leontiev production models; Kirchoff's laws; election predictions; consumer behaviour
Equations	Formulas such as D=ST; D=M/V; V=IR; SP=(1+P%)CP
Systems of equations	Mixtures; puzzles; DST; money; percents

11. Example of Just In Time Teaching

The class problem involves breakeven analysis for a student-run enterprise, such as the school yearbook. Information was provided on production fixed and variable costs, as well as probable consumer demand and selling prices. The expected mathematics content was intersection of lines. JIT teaching lessons or mini-lessons could include: (a) algebraic formulation of equations; (b) linear relations and graphing; (c) solving systems of equations by multiple methods; (d) special cases, such as parallel or coincident lines; (e) role play, such as corporate CEO; (f) communications, such as letters to suppliers recommending a course of action; and (g) extensions into quadratic relations to consider concepts such as profit; or, to examine the inverse relation between price and consumer demand.

All the lessons would be supported by practice and consolidation. The student discussion might be extended to involve What If? questions, or research to find other real life uses of the math content.

12. Groupings

Each classroom contained student desks organized in pairs. A common teaching technique involved a whole class discussion of the class problem, setting the stage for student activity, followed by students working on the problem in pairs or groups of four. Some teachers who were more comfortable with whole class activities allocated the major portion of class time to solving the class problem as a whole class. Other teachers utilized a mixture of whole class and pairs or groups. One teacher frequently allowed students to attack the class problem as pairs, without any initial whole class discussion. Depending on the topic, additional student activities, such as role play, library research, or communication activities such as letter writing to argue a position, could be used to enhance student learning.

13. Technology

Available technology was routinely used as problem-solving tools. The typical technology of the day was scientific calculators. Students were allowed to use calculators at any time in their work. This allowed the problems to be much more real life, since in real life problems are often “messy” and involve messy, unfriendly numbers. Using calculators also freed students from using tables of, for example, trigonometric ratio values, or logarithm tables. An important part of using technology appropriately was to teach students good estimation skills, and imbue them with an “estimate then calculate” mentality. This philosophy on the use of technology at any time was controversial at the time. The department head faced vociferous complaints from parents, and attended a number of school council meetings to defend the department's position. As a teacher in the department, my reaction to the technology use was that it was incredibly freeing. No longer did I have to invent problems with “nice” numbers, or interest rates that were tabulated in the back of a textbook. The problems could actually use real world data.

14. Other Dimensions of the Program

The department program also recognized metacognitive needs of the students. Students were taught (a) notebook keeping skills; (b) summarizing skills, based on creating weekly summaries, followed by monthly summaries, which summaries could be used on tests and evaluations; and (c) test taking skills. The department provided major test schedules, so that students could plan their test preparation appropriately. This practice was adopted by the entire school, and a large major test calendar was placed in the school office, where students could consult it readily and all teachers entered test dates for their classes. In mathematics, the major tests were cumulative, in recognition of the cumulative nature of mathematics content.

15. Discussion

Figure 2 illustrates a logic model for this case study. The attributes of the incoming students mitigated against the students arriving with positive attitudes towards the school or mathematics. Their previous experiences with mathematics consisted of traditional transmission model, i.e., theory followed by applications. The condition of the school building exacerbated these negative attitudes and could have potentially resulted in increased absences, class management concerns, reduced engagement, and decreased achievement. However, the outcomes in this case study did not support this conjecture. All teacher participants in the study reported high levels of student motivation and engagement. Student attitudes were generally seen as positive, and some students exhibited very high levels of interest in their mathematics classes. The proposition that teaching through problem solving increased student achievement could not be supported. Although there was anecdotal evidence that failure rates were at least on levels that the teachers had experienced in other schools, no archival records were available to support this claim. Additionally, only limited anecdotal reports concerning student self-efficacy were available. The effects on student achievement of teaching through problem solving are not supported by Hattie [30]. Hattie's research considered only effects on achievement and not on other variables such as motivation or engagement. He found, in a synthesis of over 800 meta-analyses that teaching through problem solving had an effect size of 0.31, below the threshold of 0.40 that he considered as evidence of effectiveness. Interestingly, Hattie found that explicitly teaching problem solving techniques and heuristics had an effect size of 0.61, a very strong positive effect. In this case study however, strategies and heuristics were taught only indirectly, as teachers supported students in their problem-solving activities.

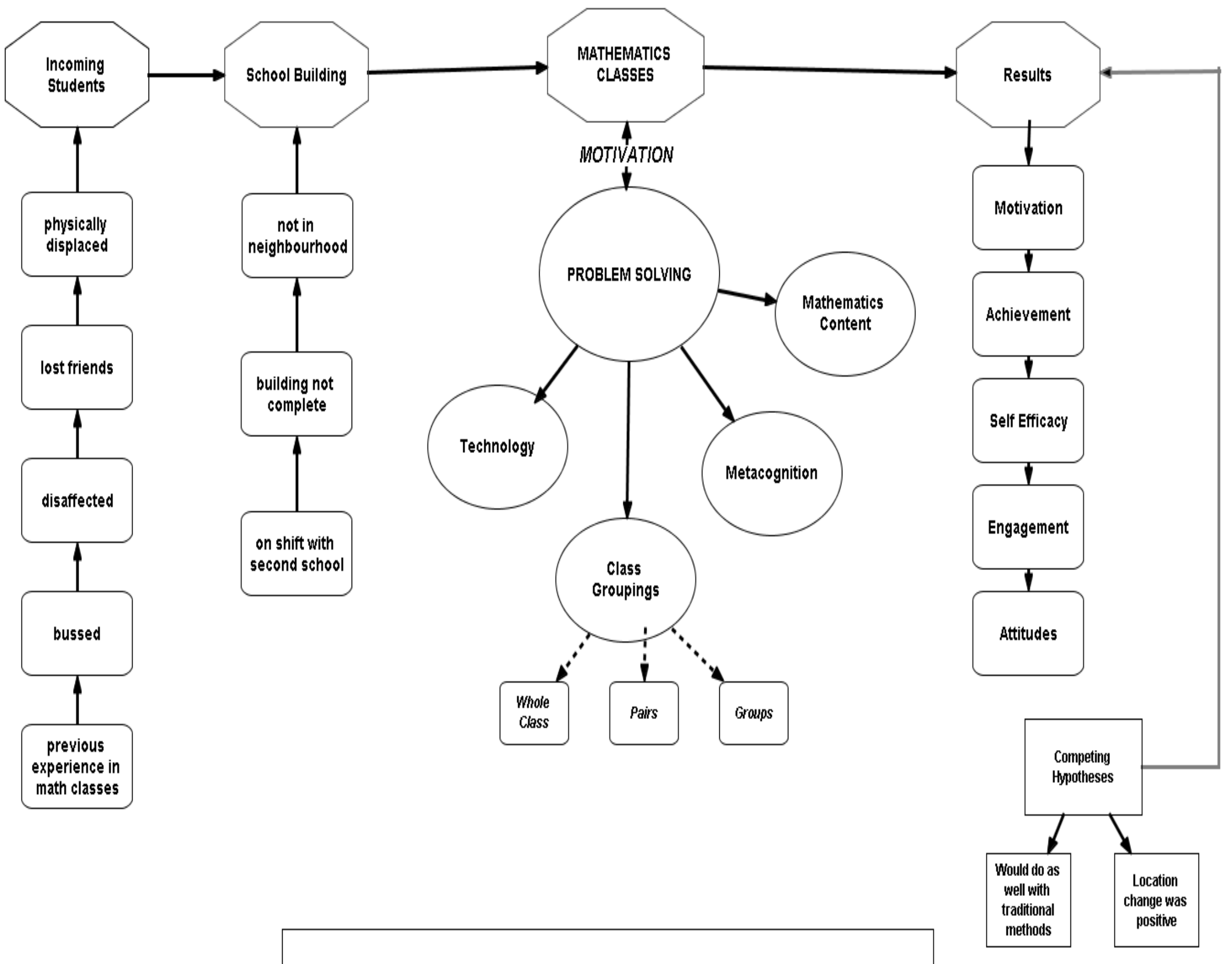

Figure 2. LOGIC MODEL FOR PROBLEM SOLVING AS MOTIVATION

16. Validity

Construct validity was addressed through data triangulation using multiple sources, including interviews with the department head, several teachers, myself as participant-observer, and artifacts related to the head's award nomination. In addition I, as participant-observer, wrote and reviewed a number of drafts to ensure accuracy. Internal validity was addressed using the logic model shown in Figure 2. External validity is supported by the wealth of research on teaching through problem solving that occurred after the time of this case study. Reliability was supported through the use of a case study protocol [26]. Teaching through problem solving has become a centerpiece of the philosophy of the National Council of Teachers of Mathematics [1-2], the Ontario Ministry of Education [3], and the U.S. Common Core State Standards [4].

This is an ex post facto study of a program that was instituted a number of years ago. As a participant in the study, there is the risk that both the program and its outcomes are viewed through rose colored glasses, and that remembered observations are biased towards positive outcomes. Triangulation was used to minimize this bias. However, the participants were all committed to the program, and collectively may remember outcomes in a biased way. Schoenfeld, discussing work by Lester, Garofalo, and Kroll, identified seven dimensions that must be satisfied in order for students to become proficient problem solvers [7].

There is a dynamic interaction between the mathematical concepts and processes (including metacognitive ones) used to solve problems using those concepts. That is, control processes and awareness of cognitive processes develop concurrently with an understanding of mathematical concepts.

In order for students' problem-solving performance to improve, they must attempt to solve a variety of types of problems on a regular basis over a prolonged period of time.

Metacognitive instruction is most effective when it takes place in a domain-specific context.

Problem-solving instruction, metacognition instruction in particular, is likely to be most effective when it is provided in a systematically organized manner under the direction of the teacher.

It is difficult for the teacher to maintain the roles of monitor, facilitator, and model in the face of classroom reality, especially when the students are having trouble with basic subject matter.

Classroom dynamics regarding small-group activities are not as well understood as one would like, and facile assumptions that "small-group interactions are best" may not be warranted. The issue of "ideal" class configurations for problem-solving lessons needs more thought and experimentation.

Assessment practices must reward and encourage the kinds of behaviors we wish students to demonstrate. [7, p. 357].

The program described in the case study addresses many of these issues, with the possible exception of the last point about assessment. Assessment practices in this program were quite traditional, with a focus on mathematics content, although the cumulative nature of major tests and the teaching of metacognitive strategies mitigated in favor of student performance.

17. Alternative Hypotheses

The logic model proposes two alternative hypotheses for student success. The first, that the location change was positive for student motivation and engagement, is not supported by the evidence and the attributes of the incoming students. The second that these students would have done as well with traditional teaching methods, is doubtful. Given the situation into which these students were placed, and the limited effectiveness of traditional teaching methods, it is unlikely that the same level of motivation and engagement could be attained without the emphasis on real world, student-relevant problems, supported by the just in time teaching, which obviated the need to demonstrate the usefulness of mathematical theory devoid of application.

18. Limitations

One limitation of this case study is the unique setting and sample. The unit for this case study was one specific mathematics department consisting of eight members, all of whom shared a common philosophy, and all of whom worked together in a cohesive, cooperative professional undertaking. In addition, the school setting was also unique, the first year of operation, an incomplete building, and generally disaffected students who had been displaced from their previous physical location and peer group.

A second limitation is the lack of a control group. The lack of control group limits the causal implications of the study. All students in the school participated in this program. While the proposed alternative hypotheses were not supported it is possible that an additional external factor influenced student performance, rather than the problem-solving program described in this case study.

Finally, this was an ex post facto study. Consequently, some data was no longer available, specifically individual student achievement data. In addition, since all the participant teachers were committed to the program, there may be a tendency to a positive bias in responses discussing a program that occurred in the past. Certainly, not all class problems were equally successful, as indicated in the discussion above. Moving forward, specific class problems were revised or replaced to improve efficacy. This also allowed for more teacher choice, selecting from a panel of class problems that could be appropriate for a specific content topic.

19. Future of the Program and Succession Planning

Several of the teachers interviewed recalled students asking before class "What's the CP (class problem) for today, sir?" Within a few weeks or months, student ownership of the program was very high. A caution should be considered here. The program occurred over 30 years ago. Teacher recollections may tend to be more generous than actually occurred. In addition the program was not without difficulties. Creating realistic class problems, especially for many topics in algebra, resulted in "pseudo-problems," such as area models for multiplication of binomials. As a consequence the real-life orientation of the problems was sometimes violated. Also, this program was difficult for teachers to maintain. Schoenfeld points out that teaching through problem solving involves a high degree of commitment by the teacher, high teacher self-efficacy, and necessitates frequent, thoughtful interactions by the teacher with the students, supporting them in the problem-solving process [7]. As the school grew in size, and more teachers were added to the department, it became more difficult to maintain a cohesive problem-solving focus. While the original department members strove to remain faithful to the program, newer teachers who did not necessarily own the philosophy espoused by the original members, sometimes chose alternative, more traditional approaches to instruction. As teachers moved on to other locations and the department head retired, the dedication to the original program was significantly reduced. In addition, as research in this area increased, other, possibly more effective research-affirmed instructional strategies emerged. In problem solving, increased emphasis on problems that facilitated far transfer have become more prevalent [11]. However, the program described in this case study served as an exemplar, illustrating an instructional possibility that addressed student learning much more broadly, and across dimensions beyond a single focus on knowledge acquisition, than was extant at that time. It was an honor to be a part of it.

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