Problem Posing in Consumer Math Classes: Not Just for Future Mathematicians

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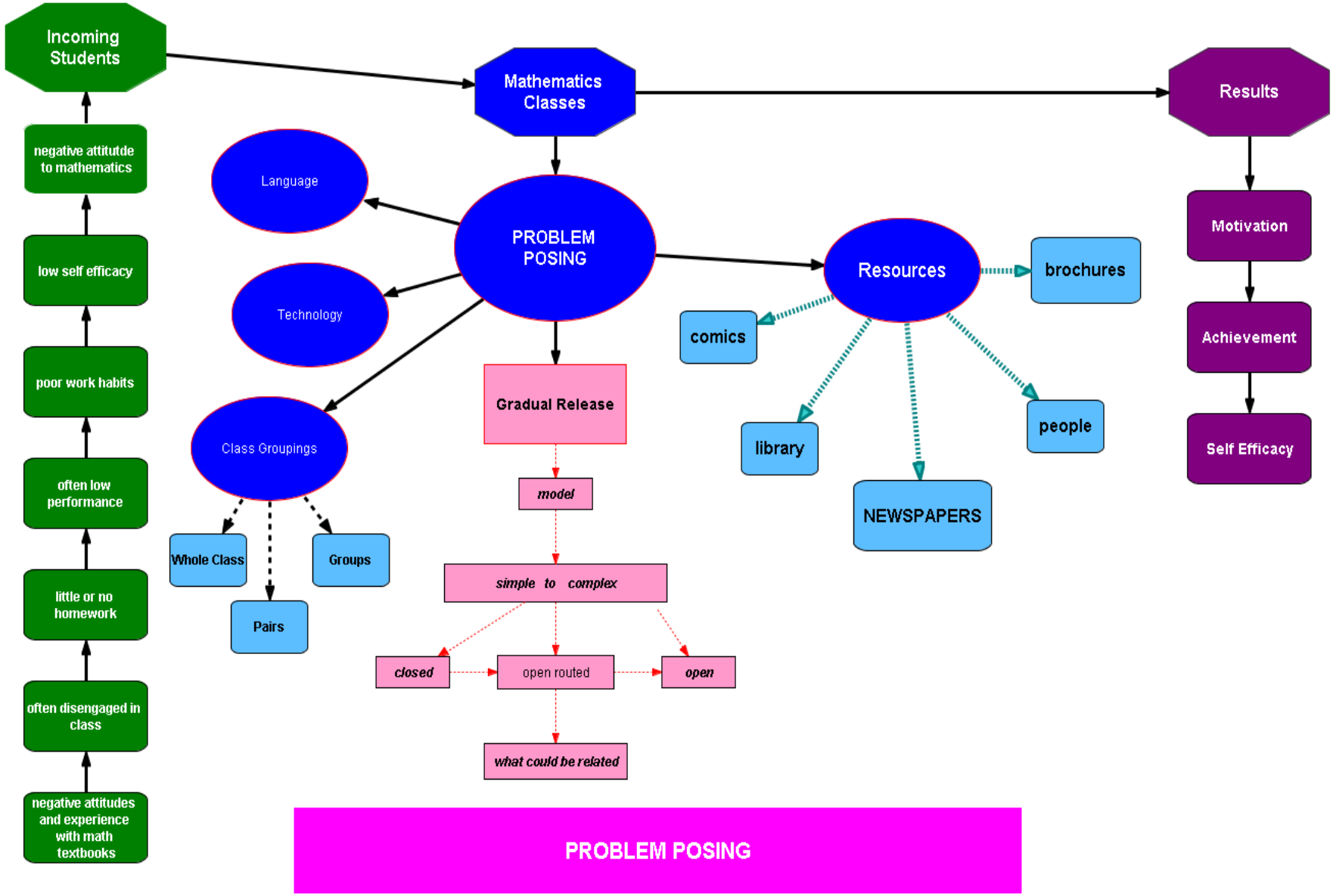
This paper describes an innovative program that I developed and taught over several years. The program, shown in Figure 1, targeted students in Grade 11 Consumer Mathematics. Students in these classes sometimes fall by the wayside in schools. My students shared negative attitudes towards school in general and mathematics in particular. They had low self-efficacy, poor work habits, and completed little or no homework in their previous mathematics classes. They were often disengaged in class, and expressed the opinion that the mathematics they had been exposed to in previous years had nothing to do with their lives. They viewed mathematics as a game in which they didn't know or understand the rules, and that mathematics was questions in a textbook, disembodied and unconnected to themselves as persons, and unconnected to anything else in their lives, not even other subjects in school.

Following are several vignettes giving examples of the program.

Vignette #1: Advertising Claims. Initially, teacher generated problems used flyers advertising sales. By concealing one or more of sale price, regular price, discount, or percent discount, students were challenged to discover what information was hidden. A major thrill for students was finding an error in the advertised information. When this happened, the class wrote letters to the advertiser, pointing out the error and asking for a correction in the flyer. This technique was also used for markup on cost, margin on selling price, percent change, investment interest rates or amounts, and other published numerical information. Very quickly, the students began posing their own "hidden


Incoming Students
negative attitutde to mathematics
low self efficacy
poor work habits
often low performance
little or no homework
often disengaged in class
negative attitudes and experience with math textbooks
Mathematics Classes
Language
Technology
PROBLEM POSING
Class Groupings
Whole Class
Pairs
Groups
Gradual Release
model
simple to complex
closed
open routed
open
what could be related
Resources
brochures
comics
library
NEWSPAPERS
people
Results
Motivation
Achievement
Self Efficacy
PROBLEM POSING

information" problems. They were also asked to engage in critical thinking. For example, "A flyer advertises 25% off, but the actual discount is 27%. Why might the store use 25% in their advertisements?" or " A flyer advertises 25% off, but the actual discount is 23%. Is this OK? Justify your decision."

Vignette #2. Depreciation. Students determined depreciation of cars using advertisements for new and used cars. They then formulated and graphed linear models. Based on real life data indicating that depreciation was not linear, they reformulated their models as exponentials. Then using their knowledge of compound interest, they determined how long they would have to save to be able to buy the used car of their choice, by finding the point of intersection of two exponential functions using technology. Their classmates were also motivated to solve the problems, since it was very much real world to students of this age, whose main goals in real life often involved purchasing a car.

Vignette #3. Prisoners. Based on an article about the number of federal prisoners in Canada, groups of students posed and investigated a variety of problems on topics such as number of prisoners per capita, by province, by gender, age, ethnicity, over time, sentence length. Some groups investigated salaries of court and jail personnel as well as lawyers. This topic was close to home for some students, since some of them had been involved in the youth criminal justice system, or had parents or relatives who were incarcerated.

Vignette #4. Guest Speakers. Guest speakers were invited when they had information that would be of use to the class. Prior to having a guest speaker, the students generated questions they wanted answered. These were given to the speaker beforehand, to ensure that the speaker's information was useful and relevant to the students. A student was always selected to introduce the guest, and another student was tasked with thanking the guest. The class always composed a letter thanking the guest. After the guest speaker, students posed and solved problems based on the information they had obtained.

Vignette #5. Role Play. Some situations lent themselves to student role play activities. For example, to apply for a car loan, students researched occupations and salaries, created a budget, completed a loan application, and role played a meeting with a bank loan officer. Other role play topics included investments, surveys and polls, accommodation decisions such as rent or buy.

Vignette #6. Comics. Newspaper comics were an excellent source of problem posing resources. A placemat activity involved each student group having a comic in the centre of the placemat. Each student generated at least one problem based on the information in the comic. The group then determined, with reasons, which problem to share with the class, in a carousel activity. A second placemat activity with comics used a comic with blank speech bubbles. The task was to outline a strategy for a specified mathematical situation, such as computing percent increase, determining commission earnings, constructing a personal net worth statement. Each student proposed statements for the strategy, and the group edited for clarity and completeness. The best edited version was written in the blank speech bubbles, and posted in the classroom.

Details of the Program

Gradual Release. It was clear that traditional instruction had been unsuccessful with these students. While they had accumulated two previous mathematics credits, there was little or no evidence of concept understanding, and no ownership of their mathematics learning. Further, student motivation and engagement were very low. For these reasons, I introduced a radically different program, focusing on problem posing and problem solving, using a gradual release model, whereby, over time, students assumed greater responsibility for formulating their own learning.

Resources. Since these students had had very negative experiences with mathematics textbooks, there were no assigned textbooks in the course. The major resource was a Toronto newspaper. I obtained class subscriptions, enabling the classes to receive multiple copies each day. This resource was supplemented by advertising flyers, brochures, guest speakers, and library resources.

Structure. Initially, I provided problems, all based on newspaper articles or advertising flyers. At first the problems were straightforward, closed questions (Vignette #1). As student competency and confidence increased, the program moved toward student-posed problems. The class then created more complex problems, moving from closed problems to open routed problems, having multiple solution paths to a single answer, and then to open problems (Vignette #3). As the course progressed, I engaged in "just in time teaching", dealing with content that arose from the students' posed problems.

Language. I was very careful about the phraseology used in class. Since "problems", especially "word problems", had a very negative connotation for these students, the

class engaged in "missing information situations". If students proposed a problem that involved mathematics not usually taught in Grade 11, they were always encouraged to explore the topic, and I structured activities to build their knowledge.

Technology. Technology, such as scientific and graphing calculators, was always available in the classroom, and viewed as tools to both increase student self efficacy by removing arithmetic stumbling blocks, and also to allow students to tackle more difficult problems (Vignette #2). Access to computer spreadsheets was available in the library, along with print resources.

Groupings and Instructional Strategies. The class used a mixture of whole class, pairs, and groups. Most activities were done in self-selected groups. Problem carousels, in student pairs, were a main feature. These carousels began with the students solving teacher-posed problems, based on newspaper articles, and progressed to student problem posing activities, again based on newspaper articles. There was also frequent use of jigsaw, stay and stray, and placemat, as well as activities that promoted student critical thinking and evaluation, such as judging the best or most interesting carousel problem posed by a student pair or group. These judgments had to be supported by reasoned arguments, without invoking personal attributes.

Assessment. Traditional tests were preceded by jigsaw activities, in which student groups posed questions, and passed them on to other groups, who generated solutions. The test then consisted of a mix of similar (sometimes identical) problems. As student competence and confidence increased, tests became based on today's newspaper.

Individual students or pairs were asked to pick a newspaper section or article and generate a specified number of problems based on these resources. Some tests contained more structure, whereby students could be asked to generate three questions based on one newspaper article, with the questions involving three different mathematics topics that had been studied; or, given a newspaper article, generate one question, then two "what if?" questions, where the constraints were changed. In all cases, the expectation was that students would also provide solutions to their problems. The final exam in the course was similar to a class test, with a mixture of teacher-generated problems to be solved, and student problem posing tasks. All these problems and tasks were based on newspaper articles.

Both work portfolios and showcase portfolios were also used extensively. The work portfolios were used to keep students' work organized. These portfolios might be individual, pair, or group, and group membership could change based on flexible groupings, depending on the task. The showcase portfolios were part of student evaluation. For these portfolios, students chose their best work, according to criteria provided by the teacher, and included written justification for their choices, as well as reflections on their learning. The showcase portfolios were assessed using rubrics. Initially, the rubrics were teacher generated. As the semester progressed, the rubrics became co-created, and subsequently, student generated. Journals were also a major feature. Weekly entries consisted of two portions. The first portion was always "This week in math". In this section, students identified their best work for the week, asked clarifying questions, and identified areas of difficulty. The second part of the weekly journal involved a sentence stem that focused on metacognitive or affective attributes.

Examples of sentence stems include "My study plan for the test next week is ..."; The activity I liked best this week was...because..."; "I feel confident that I understand (topic) because...". This portion of the journal could also include a Likert scale on attitudes towards mathematics, self-efficacy, or interests.

Summary

This was a very successful program. There was evidence of significantly increased student motivation and engagement, including the following anecdote. Over 3 years of this program, a number of students began going to the school library before math class, to read the newspaper before their classmates. The librarian complained that frequently articles had been cut out of the library copy of the newspaper. The students were posing problems based on these articles before they came to class, engaging in mathematical problem posing on their own time. I made an arrangement with the library, that every day, we would take one of the class copies of the newspaper to the library, to replace the copy that my students had defaced. I was excited that these students, many of whom had never voluntarily entered the library during their high school years, were actively engaged in problem posing and problem solving. This was an indicator of the program's impact on student motivation and engagement. There was also increased student ownership of their learning. One student remarked "We do a lot of problems in math class, but they're *our* problems." More traditional measures also provided indicators of success. Attendance records showed decreased rates of absenteeism, and report cards showed decreased failure rates. The students and I looked forward to this class every day. I loved teaching this program, and I left the program only due to a change in my role in education.

To implement this program in other settings, the following conditions are necessary:

- teacher flexibility
- administrative support
- some flexibility in curriculum

As you can see, there are not a lot of barriers to implementation. In many jurisdictions, curriculum inflexibility may be the biggest hurdle. However, the program can be implemented, perhaps on a somewhat more content-restricted basis, in any classroom where student motivation is paramount.