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A Problem Solving Medicine Wheel

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Abstract: We use a Medicine Wheel to describe our professional understanding of the nature, teaching and learning of problem solving. We developed this understanding via a professional learning project over several years, and based on our observations of children's efforts and struggles to solve rich and open-ended mathematical problems.

Keywords: Problem solving; professional learning; teaching and learning problem solving

Introduction

As elementary teachers and a researcher, we started with a question inspired by our own teaching and our own professional learning needs. We wanted to be able to improve our ability to teach problem solving. We had seen too many students struggle to solve problems. Too many times, we observed children refuse to even start the problem, to the point where we wondered at the wisdom of using rich and complex mathematical tasks (Munter, 2014). Shouldn't we use easier tasks, to ensure success; but then, we still observed children struggling. Even children who seemed to succeed didn't really succeed because their problem solving abilities were isolated to the particular context of a problem. We embarked on a professional learning journey framed by lesson study, as we recognized the potency of this approach (Fernandez, 2002). Our driving goal

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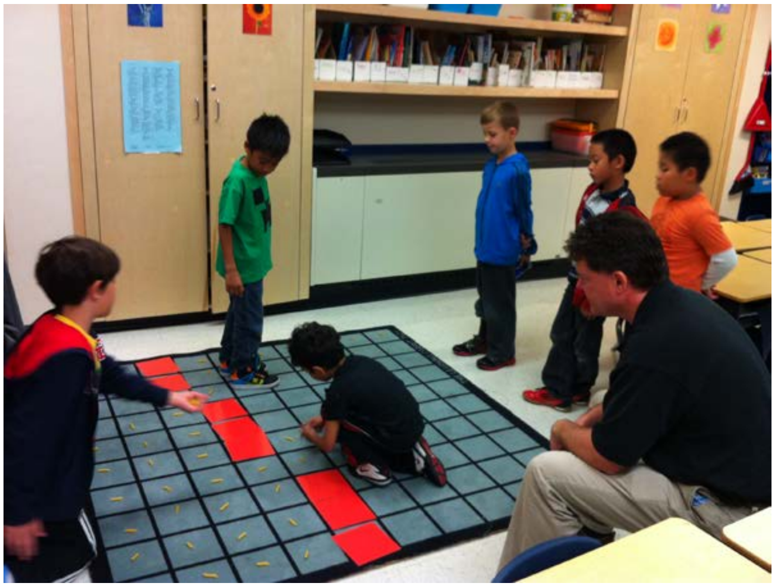
was to develop professional insight in a robust sense of problem solving. As one teacher noted at our very first planning meeting, “I want my students to learn how to solve problems, whether they are mathematical, scientific, social studies, or even conflict resolution on the playground.” Several years into our journey, we feel we have developed a rich understanding of the nature, teaching and learning of problem solving.

In this paper, we will focus on one aspect of our emerging understandings of a nature and pedagogy of problem solving, in the form of a problem solving Medicine Wheel. The educational needs of First Nations People are at the forefront of all teachers in our locale, with many opportunities for professional development in this area. It is not surprising that a connection was made between two areas of professional learning that were important to us. More encouraging was that the school division Elder was pleased with our use of the Medicine Wheel. Our story is one of observing children try to solve challenging problems. In listening to children, we discovered we needed to adjust our sense of the nature of problem solving. This shift led us to a Medicine wheel to understand the nature of problem solving, which now also serves as a pedagogic tool. In what follows, we describe the development, meaning and use of our problem solving Medicine Wheel.

Snap Shots of our Professional Learning Journey

To begin illustrating the development of our problem solving Medicine wheel, we start with one of our very first problems, tried in a grade 2/3 classroom. The Mouse in a Maze Problem involves a pretend mouse exploring a room to find food. The more of the room that is explored, the more likely the mouse will find food. The mouse must find a path through a grid of the room without visiting the same square more than once and must return to the starting point. Figure 1 shows children working on the problem, where the room and grid is represented on a learning carpet. We modeled for the class the problem on a learning carpet, then had the children work with a partner on a learning carpet or worksheet, and closed with a class discussion on the strategies they used to solve the problem.

Figure 1 – Children working together on the Mouse in a Maze Problem



We chose this problem because there are many solutions and possibilities, which allowed us to respond to the diversity of the classroom. We anticipated that some students would find a solution quickly. We could challenge these students by asking them to find another solution, and we also had a different maze these children could try. The original problem stated that the path must visit every square in the grid. We decided to drop this condition – the path didn't need to visit every square. We felt this would help some of our students to be immediately successful with a short path. We could then challenge these students by asking if they could find a longer path that covered more of the room. We also anticipated that some students would prefer to work on the problem at the learning carpet, rather than on a work sheet. We felt this problem could respond to our past concerns with addressing the diversity of math abilities in our classrooms. Without realizing it, we had developed a problem solving activity with what Boaler (2014) calls a low-floor and high-ceiling.

All of the children were engaged and worked on the problem for over 30 minutes. Some found more than one solution whereas others found paths which didn't cover the whole grid. The children developed a variety of strategies to record a path using manipulatives, arrows or a continuous drawn path. Contrary to our past experience with students who struggled with problem solving, this problem engaged all the children, so that the simple scaffolds “just try something” and “what if you try something else” encouraged students to start thinking and keep thinking. We also noticed that the notion of success was diverse and anchored by observing different problem solving strategies, including perseverance and representing the path.

Another problem we tried in a grade 4/5 classroom involved searching for an optimal solution. Given a grid to represent a neighborhood, and five houses in that neighborhood, find a location on the grid for a playground that is fair to the five houses. Figure 2 shows the launching of the playground problem on a learning carpet, where the red squares are the locations of three of the houses and the wooden block is the class’ first guess on a location for the playground. We decided to be vague about the meaning of fair as a way to encourage creativity and differentiate the problem. We launched the problem on the learning carpet and then had the children work in small groups on a worksheet (two groups could choose to work on a learning carpet), and we consolidated by focusing on strategies rather than an answer. Although there is a mathematical notion of fair (optimizing average distance travelled to the playground for each house) that produces one correct answer, we were open to alternative approaches, and were ready to encourage students even if they deviated from the expected solution.

Figure 2 – Launching the Playground Problem on a learning carpet

All groups came up with a similar notion of fairness, consistent with the expected mathematical notion of optimizing average distance. We observed students trying two or three locations and stopping. “Is this enough,” we asked or, “is this the best location?” These prompts were enough to re-initiate and sustain the thinking of the children. Again we observed several problem solving strategies, including different ways of representing the problem (written, hands-on or kinesthetic). Figure 3 shows one group of children working on the problem. Although no group came to a final solution, and all groups struggled, it was clear that the problem was a success in terms of children’s sense making around trying to solve problems.

Figure 3 – Children working together on the Playground Problem

After trying several different problems in different elementary grades, our debriefing sessions were facilitating a shift in our views of the nature of problem solving. We realized that perseverance as a problem solving strategy can be experienced in more than one way by children. These kinds of perseverance are try something, try something else, and try something different. As one teacher noted in a debriefing session, “some children can think ahead better than others; some have to just do it and not think ahead.” We were on the verge of realizing a fundamental quality of the nature of problem solving.

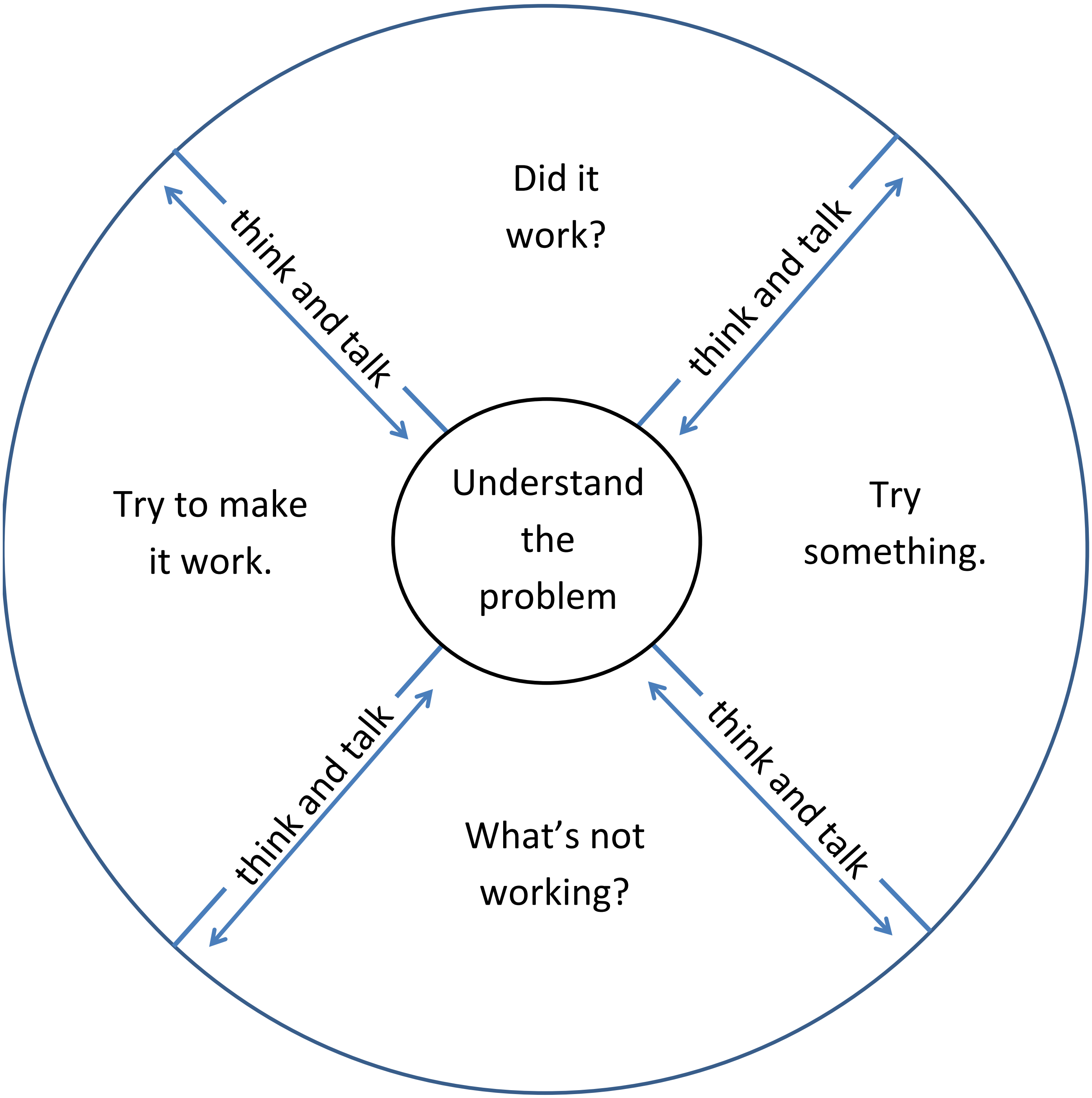
From our observations of the decision-making of children, and our responses to the children to initiate and maintain their thinking without telling them what to do, we began to build a new model of the nature of problem solving. We noticed that the reasoning of children in their decision making had an “if... then…” structure. We tried to build a problem solving heuristic much like a computer program, by linking together problem solving activities into a “program” of decisions of the form “if this happens then do this otherwise do something else.” This visualization of problem solving seemed incomplete and overly complicated. We did notice that, like a computer program, a subset of activities could repeat itself – it was cyclical and iterative.

That our heuristic description of problem solving was cyclical and iterative shocked our sensibilities. It was later in our professional journey that we discovered others writing about the cyclic nature of problem solving (e.g., Carlson & Bloom, 2005). We had all learned Polya's (1945) four step heuristic (understand, plan, enact, look back), which was assimilated into a linear sense of problem solving, and reinforced by problem solving experiences (as teachers and learners) where you either got it (proceeded directly and immediately through the steps) or didn't. If problem solving is not linear (a straight line metaphor), then it must be a cycle. It must be a circle. Eureka! It must be a Medicine Wheel.

Our Problem Solving Medicine Wheel

We built into a Medicine Wheel our observations of problem solving (see Figure 4). We placed "try something" in the East of the Medicine Wheel. In the South, West and North we placed "what's not working," "try to make it work," and "did it work," respectively. These phrases are like scaffolds, reminders, or thinking prompts; they are motivated by our observations of children's thinking and the teacher scaffolds we used to sustain children's thinking. Always start in the East, and move around the Wheel to the South, West and North. A cycle emerges because the North leads into the East by "trying something" again, hopefully anchored in children's reflection and/or thinking ahead. The Medicine Wheel helps us to render visible the cyclic nature of problem solving and the kinds of perseverance we had been observing. We used the spokes of the Wheel to emphasize that we should keep thinking together. In the hub of the Wheel we placed "understand the problem" because we had learned that understanding stretches throughout the process, that it is a process of increasing understanding, and that the process of understanding doesn't stop when we move to the second step of Polya's heuristic.

Figure 4 – Our problem solving Medicine Wheel



Consistent with Schoefeld (1992), we felt that children needed help to be aware of the problem solving strategies they and their classmates had been using – a metacognitive emphasis. So, we decided the Medicine Wheel can be a pedagogic tool to develop children's meta-awareness of their problem solving abilities and strategies. We don't introduce the Medicine Wheel immediately. Rather, we slowly build the Wheel as we do problems, and observe and label children's strategies of perseverance (and other strategies used by the children). We are building from the children's work, rather than telling the children the Wheel from the beginning. Without fail, we observe these kinds of perseverance, which allow us to build the wheel based on children's efforts to problem solve. Consolidating a problem and introducing a new problem emphasize these observed problem solving strategies.

Eventually, we introduce the entire medicine wheel. Consolidation focusses on having children reflect on the medicine wheel in their own thinking. The medicine wheel evolves into a general heuristic that the children can use when problem solving. When children don't naturally use the medicine wheel and are struggling, our first scaffold is, "would the medicine wheel help?" Responding to our original goal for professional learning, the medicine wheel is always displayed in the classroom. It can be referred to during inquiries in other disciplines. It has been effectively referenced while problem solving with children concerning conflict that arose on the playground during recess.

Often, the problem solving medicine serves to re-initiate thinking. For example, if a student is using a guess a check method to solve a problem, asking a student to locate their progress on the Medicine Wheel helps them to realize something they could try next. "What's not working" sometimes serves as a cue for a student to consider changing the strategy they are using to solve the problem; this "shifting of gears" by a student is a more refined version of perseverance because the student is also trying something new. Although the Medicine Wheel focusses a student's meta-awareness on general aspects of problem solving and its cyclical nature, its emphasis on different types of perseverance leads to students recognizing math specific problem solving strategies, such as modeling the problem (e.g., using a manipulative or visual) and logical reasoning (e.g., if this is true then that must also be true). Thus, consolidation after using the medicine wheel to work on a rich and open-ended problem can lead to student's to meta-awareness of perseverance, as well as other problem solving strategies.

Conclusions

Hiebert and Grouws (2007) suggest that children must struggle to learn math deeply. Learning is not equivalent with an easy or simple experience. Rather, struggle is a necessary condition to making sense of mathematics. Productive struggle is a term we coined partway through our professional learning journey. We had recognized the problem with trying to make mathematics learning easy. We are also remembering our concerns with children who have negative experiences with mathematics. Telling students how to solve a problem may eliminate stress for a child, but it may also mitigate against any significant sense making by a child about problem solving and mathematics. We are always providing guiding scaffolds to children: we "tell" students ideas that label and encourage their thinking. Productive struggle is our pedagogic reminder to resist telling students what to do while also mitigating against excessive frustration. After-the-fact, we learned that other teacher educators were writing about children struggling to learn mathematics that is positive and productive (Bray, 2014; Clarke and Clarke, 2003; Warshauer, 2015). As these researchers have done, and contrary to our initial desire to eliminate struggle, we have found that we can cultivate perseverance by our children, even with those with negative past experiences with, and attitudes about, mathematics. From our experiences, we fully endorse and see the potency of the common core standard to "make sense of problems and persevere in solving them" (CCSSI, 2010). Our observations of different kinds of perseverance led us to coin the phrase productive struggle, which is embedded in our problem solving Medicine Wheel.

We believe that the tasks we developed were critical to noticing and fostering productive struggle among all of our students. We coined the phrase naturally differentiated problems to describe the critical qualities of our problem solving activities. The core problem has a low-floor and high ceiling (Boaler, 2014); there are multiple entry and end points. The core problem can be solved in many different ways. Our tasks are rich and open-ended, and appropriately launched and consolidated (Munter, 2014). We launch with the goal of engaging children and igniting their initial (but not complete) understanding of the problem. The children understand enough and are engaged enough by the launch to start working on the problem, to try something. Our launches are often kinesthetic, and always include some sort of engaging context (such as a story we invented or a children's book). We have developed our abilities to sustain children's thinking with appropriate scaffolds while they work together in small groups on the problem. During the consolidation phase, we always focus children on their problem solving strategies, rather than on the final solution. We want problem solving ability to be the learning goal of these activities, and we have found that this goal can be met without finding a solution; further, emphasizing the solution becomes a negative experience for those children who did not come to their own sense of a final solution.

By listening to children, we have significantly enhanced our understanding of the nature, teaching and learning of problem solving. In particular we have shifted our professional dispositions from linear to cyclic, and from protecting children from struggle to facilitating productive struggle. These dispositional shifts play across the nature, learning and teaching of problem solving. We conclude by noting a growing intuition of another shift in our thinking. We label problem solving strategies that children use as a metacognitive turn, not as an indication of the components or skills of problem solving. In doing this, we are beginning to shift our perception of problem solving from a collection of individual skills in favor of a holistic rendering (Schoenfled, 1992). Rather than try to teach individual problem solving skills in isolation, we are beginning to see problem solving as the same as learning by struggling. If a child does not struggle to solve a problem, then the activity wasn't experienced by the child as problem solving. Our problem solving Medicine Wheel, by its very nature and heritage, reflects a holistic view of problem solving. We use the Medicine Wheel to develop problem solving ability as a holistic experience – all of it in play at all times.

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