Strategies for Promoting Problem Solving and Transfer: A Qualitative Study

By Janet Bagby and Tracey Sulak

The world of today may not be reflective of the world our students will inherit. Increasing globalization has led to a loss of unskilled jobs through outsourcing to countries with lower labor costs (Tucker, 2007). The loss of these jobs requires schools systems to prepare a different kind of student to fill the remaining jobs. Today's student must be able to integrate knowledge and then use the knowledge in varied situations; in short, this student needs to master not only the traditional curriculum but also learn to problem solve and transfer solutions to new contexts.

Problem solving allows students to use what they know to achieve a goal when no solution is apparent (Jonassen, 2000; Mayer & Wittrock, 2006). Traditional educational models evolved from an earlier system, based on rote memorization and designed to produce employees for industry (Lageman, 2000). The workforce of tomorrow must move beyond rote learning by both applying current knowledge and using problem-solving skills to understand the issues of tomorrow. Since many of the problems of the future may not exist in today's world, teachers must prepare students to meet challenges that may not have immediately teachable solutions. In order to solve these problems, students need to employ transfer, or the ability to use prior learning to understand new information (Mayer & Wittrock, 1996). This article describes a qualitative study, the purpose of which was to examine the use of problem-solving strategies and instruction within a Montessori environment.

The research site was a private Montessori school for toddlers through sixth grade. Participating in the study were 16 students, one lead teacher, one assistant teacher, and one parent of each of the 4th–6th-grade-level students. This upper elementary environment was chosen because the majority of these students had been schooled in the Montessori model of learning for a number of years. Many of these students entered the school at age 3. The data collection included approximately 60 hours of videotaped lessons, class observations, and interviews with students, teachers, and parents. The multiple sources of information and collection methods provided a means to validate the data and strengthen the findings.

According to research (Mayer, 1987; Mayer & Wittrock, 1996), specific instructional strategies encourage problem-solving transfer and have a positive effect on the quality of the process. Therefore, this study was guided by the key question, "What Montessori model characteristics are similar to those characteristics reported in the research on problem solving to facilitate transfer?" The quality of the learning and the depth of understanding were two key strategies examined in this study.

Quality of Learning

In problem-solving research, quality refers to how meaningful the learning is for the learner (Brooks & Dansereau, 1987; Mayer, 1987). Incorporating instructional methods, such as discovery learning, concrete manipulatives, and connecting old and new knowledge, encourages meaningful learning (Mayer & Wittrock, 1996). Meaning has to do with the way a concept is embedded in a weblike array of related concepts. The more connections made to other concepts, the richer the meaning of the information (Halpern, 1998). Problems that have real-world applications and are generated by students

are particularly powerful (Eggan & Kauchak, 2001).

When students are involved in quality learning experiences, they are more likely to transfer the general principles of learning to situations outside the classroom. In Montessori classrooms, the cultural curriculum strand interweaves science, geography, history, social studies, and the traditional core subjects, such as math and language arts, so students rarely receive facts in isolation. Multiple connections between old and new knowledge allow students to place new learning in the context of previous learning. Linking new learning and old learning also helps students form connections between concepts and may contribute to transfer (Moreno, 2009).

One example of the quality of the learning experience occurred during an experiment on convection currents in the upper elementary environment. The teacher connected the new lesson with previous experiences when she explained that the experiment was preceded by a series of lessons on the layers of the earth and plate tectonics. This experiment was in preparation for the next lesson that would cover oceans and ocean currents. The students conducted the convection experiment without teacher supervision or intervention. In describing the process, the students used a research form that was used for all experiments. On the form, the students described the experiment, the materials needed, and the steps and procedures. The lead teacher described the rest of the process:

> *There is a place where they stop and make a prediction of what they think is going to happen or a hypothesis, what they foresee happening in the experiment. And then at that point, after they have hypothesized and talked about that as a group, they may have one or two within the group of different predictions, they get that recorded and then they go ahead and perform the experiment.*

Advanced work with triangle boxes

This lesson was also an example of discovery learning because the students were testing their hypotheses and generating connections. They were actively involved in questioning and applying their knowledge to understand the experimental process.

Connecting old and new knowledge is an important part of the Montessori curriculum. The lead teacher for the classroom described this process:

> *One of the basic tenets . . . is the interconnectedness of all things. That is why in the curriculum you do not do just science or geography or history. You do those things but they are all bound together and called the cultural subjects. . . . . You don't learn anything in isolation. It all has a purpose. . . . It all has a place where it fits into a bigger scheme and bigger picture.*

In another lesson, the 5th-grade-level students were engaged in a discussion with the assistant teacher about the book they were reading. The goal of the lesson was for the students to understand the concepts of protagonist and antagonist. Sitting in a circle on the carpet in front of the students, the teacher began the lesson by relating previously learned information to new information:

> *Remember the attribute blocks? Do you know where those attribute blocks are? Why don't you get a few and let's talk about that for a minute because that will be a good thing for you to relate to, to help you understand where I'm going*

Collaborating on problem solving

with the lesson today. Do you remember what you did with the attribute blocks? Can someone come up very quickly and do something with the attribute blocks? Let's think about what this circle will be, and let's think of what this one will be.

Following this discussion on previous activities with a Venn diagram, the assistant teacher said:

Okay, now we are going to do something with your novel that is kind of like this. Only we are going to do it with characters in the story, and I want to talk to you a little about it, but first we are going to give some terms to the characters just to introduce them to you a little bit. Have you ever heard of the protagonist?

Just as the assistant teacher used the attribute blocks and Venn diagrams as a strategy for understanding connections in a literature lesson, the lead teacher used a similar approach in a biology lesson. One of the major topics in the Montessori biology curriculum for grade levels 4–6 is the Timeline of Life. This topic is initially introduced to the students in the lower elementary curriculum. The content for the upper elementary level continues the emphasis on the interrelatedness of life with a focus on plant and animal development. The lead teacher shared the following description of how a student connected previous knowledge with new knowledge and how the biology time line information was meaningful for this student.

We were studying the time line with the fourth graders, and we were talking about the plants and animals. . . . So they were talking about how the plants go back into the earth and fertilize the soil, and then more plants are able to grow, and then the animals are able to use them . . . and one of them said, "Hey, wait a minute, that is just like the circle of life. That is what they mean by the circle of life, now I understand."

We have charts in lower elementary that show circles of life, you know the nitrogen cycle or the water cycle, and she was connecting that that was circular in pattern and cycle. And when we got to simultaneous study of the ocean, we were talking about the water cycle, she said, "That is another one of the circles, another one of the cycles." So she began connecting that way.

Lessons that are embedded in real world contexts or that employ "situated cognition" facilitate transfer beyond the classroom (Lillard, 2005). Maria Montessori (1965) attributed the ability to make connections between situations to the child's sense of order, a premise developed throughout the Montessori philosophy. A traditional curriculum does not typically foster the development of problem-solving skills because the student rarely faces situations that do not have immediate solutions (Schunk, 2008). Maria Montessori developed the Montessori curriculum to establish a framework for knowledge set in meaningful contexts, and this combination contributes to the transfer of problem-solving skills beyond the classroom (Lillard, 2005).

Depth of Understanding

The more time spent learning to solve problems (Gick & Holyoak, 1987), and the more opportunities learners have to practice (Cormier, 1987), the more likely problem solving will transfer. Brophy (1992) discussed the importance of depth of understanding versus the acquisition of content knowledge. To expect transfer, it is necessary to teach the underlying principles rather than the simple accumulation of the knowledge (Alexander and Murphy, 1999).

This 4th–6th-grade-level classroom afforded many opportunities for depth of understanding. One parent stated, "They learn things so well that

they don't forget them. I mean, they are ingrained in them. They don't learn things to pass a test. They learn things, and this is knowledge they will have forever."

In the interviews, students and parents provided comments and examples related to the depth of understanding in the curricular strands. For example, the following student said he had been working on this particular research "since January," and the interview was conducted on February 29th.

Student: *We are doing research about the ocean, and I guess that is pretty fun. . . . We are also doing independent study projects, all of us, and I'm doing dummies. We are researching that but everybody has their own independent study thing.*

Parents had the following to say when asked,"How would you describe Montessori education?"

Well, the first word that comes to mind is just hands-on*, and learning to think independently. So much of the work is designed so that the child pretty much has to think through conceptually what they are doing rather just memorizing something or learning something just again kind of on a superficial level. This way they have a deeper understanding. Probably the overall term that always comes to mind is just the hands-on experience, where you are working through it yourself to learn and to understand.*

Last year, when they were studying all of the plants out in the desert area, we would drive and he would identify them. He would identify the plants, and he would tell me how often they bloom, or he would say, "That one is in bloom and it doesn't bloom but once every four years; so, look at it this year because it's going to be four more years."And he knew so much more. . . . And I think that today he could still drive down that street, identifying that plant, and tell you facts about it.

These parents' comments illustrate their belief that the Montessori curriculum provides students with contextually rich learning opportunities. Active learning, which requires effortful processing of information, may contribute to the transfer of problem-solving skills through encoding of the concepts and creating meaningful connections (Bereby-Meyer & Kaplan, 2005).

Lost in a book

In summary, the Montessori model of learning, as demonstrated in this upper elementary classroom, has characteristics similar to those characteristics reported in the problem-solving research. Specifically, the two instructional strategies of the quality of the learning and the depth of understanding were evident in the videotaped lessons, the interviews, and the Montessori curriculum.

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