I’m not very big, but I’ll do my best

Becoming a Problem Solver

Over the past ten years, I have attempted to identify the characteristics of young children as they grow and mature as problem solvers by conducting an action research project in a first- through third-grade classroom. Teaching in a multiage classroom gave me the opportunity to observe children over a period of three years and to document their progress using various types of assessment. I observed children while they were engaged in the act of solving problems and sharing solutions with others. I interviewed children as they solved problems and I scored their written work using a scoring guide, or rubric.

In this article, I describe seven stages in the development of children. Knowledge of these stages has helped me to set more realistic expectations and to turn solving problems into more positive experiences for my class. As I examined children’s solutions to problems, I became acutely aware of major differences in the ways that children and adults think and express their thoughts. Awareness of these differences helped me to shift my focus toward what children can do rather than what they cannot do.

Although this article presents the seven stages in a linear manner, not all children develop problem-solving abilities in this fashion. In addition, not all children display all the characteristics of a particular stage when solving individual problems. As Graves and Stuart noted, “If there is one rule that applies to every child, it is that progress is uneven. Children never follow any series of stages exactly, and sometimes appear to be regressing in one area as they advance in another” (1985, p. 169). For these reasons, the stages described in this article should be used as flexible guidelines.

A Typical Classroom Problem-Solving Environment

Each day, children in my class solve a challenging problem in a way that makes sense to them. I do not show them how to solve similar problems or remind them of specific problem-solving strategies they might want to use. I read the problem to the class and respond to any questions that the children might have.

The children solve the problem by working alone or with a partner, and I encourage them to...
use any of the manipulatives in the classroom, such as counting tiles, play money, Unifix cubes, rulers, base-ten blocks, bathroom scales, dominoes, balances, pattern blocks, calculators, the Internet, and so on. Next, the children record their solutions by showing how they solved the problem and by describing the processes they used through oral or written explanations.

While the children are busy figuring out how they will solve the problem, I move around the room and observe what they are saying and doing. I ask probing questions to check the children’s understanding of the mathematics concepts embedded in the problem, but I am careful not to give clues or to indicate how I would solve the problem.

When the children are finished, they take turns sharing their solutions with the rest of the class. During the sharing time, I observe the children’s abilities to communicate their thoughts clearly and completely and to provide useful feedback to one another in the form of worthwhile questions or comments. After all the solutions and strategies have been shared, the children compare the solutions and note similarities or differences, the reasons that some solutions are easy or hard to understand, and which solutions make sense.

**Seven Stages of Becoming a Problem Solver**

By combining my classroom observations with one-on-one interviews and scored work samples, I have identified seven stages in the development of beginning problem solvers (see fig. 1). The following descriptions of each stage include examples of children’s solutions and discussions of each solution for the following problem: “Each package has five trading cards. Mr. B. wants to give everyone in the classroom two cards. How many packages does he need to buy?” At the time this problem was presented, the class had twenty-five students.

**Concrete stage**

Angela solved this problem using a “real” deck of cards. She counted out five cards and wrapped them in a piece of paper that she glued shut so that the cards “would not fall out.” She repeated this process until she had made several packages. Next, she walked to the front of the classroom and said to all the children, “Please sit down, so I can count you.” Then Angela passed out the cards by giving some children two cards and some children one card, along with the empty wrapper from the packages. Although several children tried to tell Angela that she had given some children only one card, Angela ignored their comments. Once all the children had their cards, Angela gave a second card to all the children who had only one card. When she was finished, she walked around the room, gathered up all the empty wrappers, counted them, and announced that the answer was “ten wrappers.”

Angela used a common problem-solving strategy called act it out. Note, however, that she had not been taught this strategy, nor did she even know its name. Instead, she developed a version of this strategy on her own. Another important aspect of Angela’s solution is that she used real objects to solve the problem. Children at this stage are tied to the concrete so closely that they often need to use actual objects and directly model the actions described in the problem to arrive at a solution.

Angela documented her solution by writing “I cntfmp” [I counted them up]. Notice that her written record does not actually answer the original question stated in the problem. Instead, she briefly tells what she did and seems to see no reason to record the answer. This response is typical of children at the concrete stage; they often solve a problem, say the answer, then fail to write the answer on their papers.

**Readiness stage**

Jared counted the children in the room twice, using his fingers as counting tools. Next, he added twenty-five and twenty-five by using his fingers to count on from twenty-five. When he reached fifty, he stopped and wrote “05” [50] on his paper (see fig. 2). Then he began a new counting procedure by raising one finger on his right hand each time that he counted to five on his left hand. As he raised each finger on his right hand, he said, “That’s one [package],” “That’s two [packages],” and so on. Also, each time he lowered the fingers on his left hand, he resumed counting from where he had left off. He continued this process until he reached fifty. At this point, he said, “That’s ten.” He wrote 10 on his paper and said, “I think it’s ten.”

Jared took advantage of a manipulative that is easy to use and readily available—his fingers. He adeptly used his fingers to keep track of his counting procedure. This action marked a developmental
**FIGURE 1**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Process</th>
<th>Product</th>
<th>Communication</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Stage</td>
<td>Children use sense organs and “real” objects. Touching is believing.</td>
<td>Solutions are displayed using actual objects represented in the problem.</td>
<td>Communication is usually nonverbal. Children use the real objects to speak for them; they “show” you the answer.</td>
<td>Thinking is characterized by unconscious incompetence. Children do not know whether they have actually solved the problem. The implication is “what you see is what you get.”</td>
</tr>
<tr>
<td>Readiness Stage</td>
<td>Children use a mental set to get ready for, and carry out, tasks; they can use fingers as substitutes for real objects.</td>
<td>Solutions are displayed using fingers and naming the quantity represented.</td>
<td>Communication is frequently limited to simply stating the answer.</td>
<td>Children may use circular logic, restating the problem and the answer as if no steps are carried out in between.</td>
</tr>
<tr>
<td>Copying Stage</td>
<td>Children imitate others but may begin to attempt trial-and-error solutions.</td>
<td>Solutions can be displayed using traditional classroom manipulatives, but the child often attempts to use a single manipulative to solve all problems.</td>
<td>Communication is primarily nonverbal, but the solution can be represented using manipulatives.</td>
<td>Children continue to use circular logic and provide obscure reasons for the solution’s correctness.</td>
</tr>
<tr>
<td>Mechanical Stage</td>
<td>Children use the same habitual responses over and over in an attempt to solve all problems in a similar manner.</td>
<td>For the first time, children do not need concrete objects but can represent solutions using drawings. The drawings, however, must be exact.</td>
<td>Communication remains primarily nonverbal, but now children can show how they found the answer using a drawing.</td>
<td>Circular logic has become quite formalized and complex. Thinking is characterized by conscious incompetence; that is, children are aware of their errors, but they often cannot see beyond them because they are determined to use the same strategy over and over.</td>
</tr>
<tr>
<td>Novice Problem-Solver Stage</td>
<td>Children begin to use past experiences to solve new problems, but only if the new problem is recognized as similar to a previously solved problem.</td>
<td>Solutions are displayed using a variety of methods, including drawings, manipulatives, and so on.</td>
<td>Children can now show and tell. They can describe their solution processes using drawings and oral descriptions of the steps followed to arrive at the answer.</td>
<td>Thinking is characterized by unconscious competence. Children can solve problems in creative ways, but they are unable to describe the logic that leads to the correct answer.</td>
</tr>
<tr>
<td>Apprentice Problem-Solver Stage</td>
<td>Children can modify solutions to previously solved problems to fit new problems.</td>
<td>Solutions are usually represented using abstract drawings instead of manipulatives.</td>
<td>Children begin to use the written descriptions of their solutions as tools to make their thoughts clear to others and to themselves. Written descriptions often contain appropriate mathematical terminology and include some but not all of the steps in the solution process.</td>
<td>Formal logic has now replaced circular logic. In fact, children are baffled by the circular logic used by other children.</td>
</tr>
<tr>
<td>Problem-Solver Stage</td>
<td>Children create personal or new solutions for a wide range of problems.</td>
<td>Solutions are represented using abstract symbols, such as tally marks or number sentences.</td>
<td>Children can completely describe their solution processes by including all the steps used to arrive at an answer. Children can often solve the problem in more than one way.</td>
<td>Thinking is characterized by conscious competence. Children know why their solutions work and they can explain their logic to others.</td>
</tr>
</tbody>
</table>
step in his ability to represent objects in an abstract manner. Although he correctly answered the question posed in the original problem, the response he recorded leaves the reader to infer a great deal about his solution process. For this reason, teachers may wish to directly observe children at this stage while they are solving a problem and to note their problem-solving processes.

**Copying stage**

Aubrie solved this problem using an elaborate procedure of counting and moving tiles around on her desk, as shown in figure 3. She first established a baseline of twenty-five tiles on her desk. She next placed two tiles under each baseline tile. She paused for a long time as she studied the tiles on her desk. Finally, she counted five of the tiles that were below the baseline tiles and placed them in a stack, then took one of the tiles from the baseline and placed it on top of the stack. She repeated this process nine more times before she counted the stacks and said, “I think it is ten.”

Children who are at the copying stage usually use traditional classroom manipulatives to keep track of complex mental operations. Although Aubrie performed an unusual action by placing tiles from the baseline on each of her stacks, she did solve the problem correctly. Additionally, Aubrie tended to let the manipulatives speak for her; therefore, her written description lacked many of the steps in her solution process (see fig. 3).

**Mechanical stage**

Dallas’s solution (see fig. 4) is a good example of the most common feature of the mechanical stage; that is, the drawing must be exact. Children at this stage seem to reflect a need for realism that is similar to children’s strategies at the concrete stage. Children in the concrete stage progress from using real objects to using other objects, such as fingers and manipulatives. In the same way, children at the copying stage seem to progress from using real drawings of objects to using more abstract representations, such as tally marks or number sentences.

An even more important feature of this stage is that for the first time, children have a genuine written record that lets them examine, discuss with others, and reflect on their strategies. Unfortunately, this written record can be incomplete and misleading, as Dallas’s solution is. When I first looked at his solution, I could not see whether Dallas had actually solved the problem or whether he had arrived at the right answer by coincidence. His written description indicated one of two possibilities: (1) the answer was ten cards because two cards were given to five children in a row or (2) the
answer was ten packages because two packages of cards were distributed in five rows. I asked Dallas how he had solved the problem and he said, “Well, it’s five 2s in a row”; he then pointed to the children in one row and counted, “2, 4, 6, 8, 10.” Then he said, “So that’s two packages in a row ’cause that’s ten cards. So it’s two five times ’cause there is five rows and so that’s 2, 4, 6, 8, 10. So it’s ten packages just like it says [referring to the answer on his paper].” Even when a child provides a written description of a solution, talking with the child is often necessary to facilitate understanding of his or her thinking.

**Novice problem-solver stage**

Although Jamie’s solution (see fig. 5) gives the appearance of a well-conceived plan, this work does not show her first attempt at solving the problem. Jamie tried to solve the problem in three different ways before she found the solution method that would work. Jamie’s solution shows persistence; her drawing did not need to be an exact representation of real objects, and she used various symbols in creative ways to arrive at the correct answer. She was able to depict the connecting path in her solution through a combination of pictures, symbols, and words. The reader does not have to infer how she arrived at the answer even though the description of her solution process is sketchy.

**Apprentice problem-solver stage**

Trevor’s work (see fig. 6) indicates that he was aware of the importance of communicating his solution process along with the answer to the problem. He verified his answer using a second drawing, and his description included the steps that he took to arrive at an answer. In addition, he used the term because to justify his actions.

**Problem-solver stage**

Sarah’s organized list (see fig. 7) shows not only that she can use a sophisticated problem-solving strategy but also that she has good number sense and an appreciation for the relationships that exist among the numbers shown in each list. Although parts of her written description might be hard to understand, such as “so you need 2 2 times 4 packages,” her solution is complete and accurate.

**Important Points about the Seven Stages**

Teachers should keep in mind the following points as they begin to notice these stages in their students. First, young children can be at different stages in their development with respect to each of the four descriptors shown in figure 1; that is, process, product, communication, or reasoning. For example, a child might be at the novice stage in products but at a mechanical stage in communication. Second, some children remain at a stage for up to a year or more, whereas others seem to almost skip a stage altogether. Third, children who usually display the characteristics of one stage may revert to a previous stage when solving problems that are especially challenging. For example, chil-
Children who are functioning at the problem-solver level may need to use manipulatives to solve a particularly difficult problem. Fourth, as children move from one stage to the next, they are sometimes unable to solve problems that were easy for them when they were at a previous stage in their development. Some children seem to pass through a state of temporary disorientation as they reorganize their thinking into more sophisticated forms of reasoning. The brain may be going through a process similar to the remodeling of a kitchen; that is, during remodeling, the kitchen is not usable—it is not the old kitchen that it once was, nor is it the new kitchen that it will soon be. Richardson (1997) discussed this phenomenon in an interesting article that appeared in Teaching Children Mathematics. Teachers should also note that children’s development as problem solvers can be delayed or hindered if children are asked to solve problems in ways that lie outside their natural development, such as being asked to use problem-solving strategies or computation algorithms that they do not fully understand. Finally, older students may exhibit the characteristics of children at the concrete or readiness stage, but they usually spend less time at each stage in their development as problem solvers.

**Conclusion**

I would caution other teachers not to use the list of levels described in this article as a teaching tool to move children through a problem-solving curriculum more quickly. In a problem-solving classroom, teachers should give all children broad and rich experiences at each stage of their development. Then, when children are ready to move to the next level, they will have a solid foundation to build on. I have found that the best way to help children grow and mature as problem solvers is to pose challenging problems, ask children to share their solutions orally or in writing, and give them feedback in the form of questions or comments about their solutions.

When working with problem solving and young children, teachers sometimes expect beginners to display the characteristics and behaviors of novice or apprentice problem solvers. I found that children often struggled with problem solving, not because they lacked ability or mathematical understanding but because I had unrealistic expectations and did not give children the time and support they needed to complete each stage of their development. I am learning that when children are allowed to solve problems in ways that make sense to them, their natural problem-solving abilities emerge.

**Bibliography**


