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The 12 Ball Problem, or How I Stopped Hating the Assignment and Learned to Love Thinking

Years ago, in an undergraduate cognitive processes class, an instructor told us about an "unsolvable" problem: There are 12 balls, identical in appearance, but one is either heavier or lighter than the others. Using only a balance scale, and using it only three times, isolate the odd ball and be able to say in which way it differs.

I took the unsolvable problem home to my chemistry major husband. He solved it. When I showed the solution to the instructor, he said he had never considered that strategy. For years, I used that example to demonstrate obstacles to problem solving.

Just recently, I decided to use the 12 Ball Problem in a different way. I assigned the problem to my introductory psychology students. They were required to solve the problem and to submit not only the solution, but a record of their work. They were to explain the problem-solving techniques they used, describe obstacles they encountered, and show they understood the terminology. This project would constitute one-third of their grade. [As a framework, I used the four stages of problem solving described by Lester A. Lofton in his introductory text, *Psychology*.]



Realizing that a problem exists

A number of students quickly dismissed the assignment as "a piece of cake." One student said to me later, "I thought you were crazy to give us such an easy assignment for such a big portion of our grade."

I cautioned students to try to solve the problem immediately. I knew many would procrastinate, thinking the project would take them very little time.

Students even came up after class the first day, telling me they thought they had the solution already. After a couple of questions, they could see they did not. Only then did they begin to look at the assignment as "real."

Assessing the complexity

A couple of weeks after the assignment had been given, there were the beginnings of understanding.

"This is harder than I thought it would be" and "I can see this is going to require some effort" were frequently heard comments. About halfway through the term, one student grumbled that I had ruined every weekend because he could not think of anything but how to solve the problem.

A common mistake was made by a number of students who confidently offered solutions early in the term. They said it had been fairly easy to isolate the odd ball; they just could not decide if it was heavier or lighter. They were surprised when I told them their solution did not meet the requirements. Half-done was not acceptable.

Devising ways of solving the problem

One student correctly identified a very important goal of the problem-solving strategy. "The real challenge was learning how to eliminate some of the uniform balls at each weighing. That is why weighing six and six the first time would not work. You still don't know which ones are not the odd ball."

Some students tried to develop algorithms. But most plodded methodically through, using trial and error. While most of the problem solvers started at the front, some of them started at the back. "I could see the only way to get the answer was to eliminate all but three balls by the third weighing," one student wrote. "So then I set about figuring out how to get to that point in the first two steps."

Some students came upon the answer through insight. "The answer came to me while I was eating M&M's," one student reported. She then went on to explain how using the colors of the M&M's allowed her to keep track of what she knew about the balls. Another said, "I literally stumbled onto the answer." He went on to describe how he was using pennies and had them lined up on the floor when he accidentally kicked one group as he was trying a mock attempt to weigh the balls. The resulting chaos suddenly presented a novel arrangement which he found led to the solution. Another had been working on the problem before retiring for the night and dreamed about balls falling off



the scale, which led to his solution.

Many students correctly identified problem-solving obstacles. "It took me a long time to get past thinking that the only time I learned anything about a ball was when it was on the scale. Since we had to weigh them, I fixated on the scale as providing the only useful information. But we actually learn something about every ball, on or off the scale, every time we weigh any of the balls."

Students were not allowed to talk about the problem among themselves during the term, but once the projects were in, there was a lot of discussion. Many students found it was easier to identify obstacles others had met than to see their own.

Assessing whether or not we have been successful

Many students who were sure they had the solution still had difficulty working through all the possible results of weighing the 12 balls. More than once, while trying to explain their solution, they recognized they had actually met a dead end which forced them to go back and redo the work. Even when they had the answer, they had to struggle to explain how they knew they were right. Reports ranged from a one-page color diagram to a seven-page distillation of one student's ideas and attempts to solve the problem. "I knew I had done it, but explaining how I did it almost killed me," this student wrote.



Did the students learn anything about how their thought processes worked? Two students, with very disciplined math backgrounds, evidently had to do little work and had not felt a stretch of their abilities. One man with a degree in physics was taking the psychology course for enrichment. He seemed puzzled by this aspect of the assignment. "I do things like this in my work all day so it was very easy." Then he asked, "That won't affect my grade, will it?"

But the experience was enlightening for many others. Many students admitted to a grudging gratitude for the assignment. "I can't say I enjoyed doing that problem, but it made me use brain cells I didn't know I had," one student told me. I also heard expressions such as "nightmare," "industrial-strength headache," and "haunting."

A returning student said, "I think the most important thing I learned was not which ball was heavier or lighter, but that I could really do it. About half-way through I was going to quit and do another project. But then I said to myself, 'You can't give up on this.' And I didn't. I gained a lot of confidence in myself."

One student said that as he was forced to examine

his thinking processes he could see a problem that affected many areas of functioning. He noted that he often clung to unworkable methods. "Even when I knew I couldn't get to the solution by weighing six against six, I couldn't let it go. That happens to me a lot, not just on the 12 Ball Problem."

I will use this assignment again. This first time, not confident of the ability of all my students to successfully solve the problem, I gave them two other options by which to earn the same number of points. Some students did not even try to solve the 12 Ball Problem. Next time, they will all get to share the growth experience!

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