What is the difference between students given the knowledge and students with the knowledge when it comes to problem solving?

The answer is nothing, there is no difference. Based on my research, students and junior engineers with the knowledge fail to apply the knowledge that aligns with solving the problem. Middle school, high school, and students in engineering programs given the knowledge fail to apply the given information that aligns with solving the problem. There is no difference between students given the knowledge and students with the knowledge. This will not change unless students have been taught to utilize information in solving problems. Solving problems involves identifying constraints, optimizing possible solutions within the constraints, and predicting the outcome of the proposed solution.

In the Tower Problem Solving Activity students are distracted by many items including working in groups, the 20 minute time limit, and social acceptance; just to name a few. When students are given this problem less than 1% of them will develop a successful answer, mostly related to surface level details or distractions. However, if you remove any of these distractions, like not having students work in a group, the success rate will increase. Why does this happen? Students are not spending a significant enough amount of time where thinking is involved, specifically constraint identification, optimization, and applying science and math in real problem solving situations. I use the Tower Problem Solving Activity as an introductory activity, to help students learn to work with distractions and still develop a successful answer. Rather than removing distractions that will always be present, I help students go through the basic process of identifying constraints, developing a possible answer within those constraints, and working through the process of predicting the success of the proposed solution. The students are given the knowledge needed to develop the best answer to this problem, the equation. However, the students ignore the equation, as well as other constraints, and use faulty problem solving techniques. The best answer is not building the tallest tower, the best answer is building a tower that will support the most weight. The height of the tower and weight the tower will hold are inversely proportional.

If you look at the equation while thinking through possible solutions, you should see that the tallest the tower could be is the height of the classroom maybe 120 inches. Again, if you build a tower that is 120 inches tall, it will likely not hold much weight before failure. However, if you build a short even paper thin tower, it will hold more weight than a 120 pounds without failing. Based on the constraints including the time limit and equation, the best answer is to lay a few note cards flat on the floor in a way that will allow the weight to be stacked on top.

What can teachers do to improve students' application of knowledge? (1) Increase problem solving/teachable moments where students learn to identify constraints. (2) Help students work on their thinking associated with problem solving and solution optimization. (3) Find real problems at or near your school or community for students to work together and solve. (4) Get students involved in competitive robotics events and other similar problem solving activities. (5) Help students apply the math and science they are learning. (6) Help develop systems thinking in students. Everything is a system made of subsystems which are systems in and of themselves.

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Tower Problem Solving Activity

As a team of two, you are to design and construct the tallest note card tower that will withstand the most weight being placed on top of it before failure. You will have 20 minutes to design and build the tower. Each material used during the construction of the tower is associated with a point value.

Small Note Card	3 Points
Large Note Card	5 Points
1 inch of Tape	10 Points

Team scores will be calculated by:

$$Score = (\#\ inch\ of\ tape\ x\ 10) + (\#\ of\ small\ note\ cards\ x\ 3) + (\#\ of\ large\ note\ cards\ x\ 5) - (height\ of\ tower\ (in\ inches)) - \big(amount\ of\ weight\ held\ (in\ pounds)\big)$$

Note: The tower (team) with the lowest score wins.