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Measuring What Counts: Memorization Versus Understanding

A discussion on the benefits of applied learning.

BY EEVA REEDER

Eeva Reeder and a student confer about the design project. Credit: Edutopia

I was completely unprepared for the problem-solving approach I saw. I was so sure they all understood. My geometry students had just learned the formula for calculating the length of an arc of a circle. They could define it (a fraction of a circle's circumference) and could calculate the length of an arc given the circle's radius and size of the central angle. They could work backwards using algebra to deduce radius or degree measure given the arc length. They had been quizzed on these skills and not found wanting.

At the time, I was experimenting with problem-based learning, and for a unit project, I asked my students to find a way to maximize the seating capacity of a circular theater that had a rotating stage at its center. They were to improve the existing scheme and had to accommodate certain building codes and safety requirements in their redesign. Students were working in pairs and required to make a scale drawing of their final floor plan.

I did not tell them how to approach the problem. My assumption was that students would first apply the arc-length formula to sketches of various design configurations, eventually convincing themselves of the best possible design through number-crunching and reasoning, and then render the floor plan. What I was completely unprepared for was the number of students who made the drawing first -- which was bad enough. But then they attempted to calculate the seating capacity of each row by measuring arc lengths with *string laid along the curves of the scale drawing!*

In spite of the exasperating difficulty of this approach and the inaccuracies it caused, the students appeared reconciled to it, completely unaware of a better measurement tool -- namely, the formula they'd just learned. Apparently the idea that formulas were developed as a way to measure things rulers couldn't had escaped them, in spite of the fact that in the previous week we had applied the formula to solve all manner of real-world problems in the textbook.

If I'd had any confidence up to this point of the ability of traditional paper-and-pencil tests to reliably measure understanding, it was erased. I was sobered by the implications for my teaching practice. Clearly, there was much to learn about the nature of understanding, how it is developed in the learner to the point of applicability, how misconceptions arise, and how to detect and remove them.

Misconception Research

In the school design project, students apply their understanding of geometry to creating a school. Credit: Edutopia

Since at least the mid-'80s, findings have accumulated from research investigating the nature of misunderstanding. The research reveals unequivocally that the ability to memorize facts does not necessarily imply understanding of a concept. Apparently, understanding is not so much a destination as it is a point along a continuum. We may never arrive at perfect understanding of a subject, but we can deepen our understanding beyond the superficial. At some point, learners' grasp of the concept becomes deep or sophisticated enough that they can use their knowledge in a practical way. It is this level of comprehension that teachers aim for, that we qualify as understanding something. That is, "understanding" can be defined as the ability to apply a new concept in a non-textbook or classroom context; use a concept to make sense of complex, real-world situations; or express a concept in a meaningful way to others.

The problem is, many teachers mistake signs of apparent understanding for true understanding. For example, students using the right words and definitions, manipulating formulas correctly, or answering questions with borrowed opinions give the impression that they understand. And in fact they may, since someone with understanding can do those things, but it is also possible to do them without understanding. Therefore, it is simply not safe for a teacher to infer understanding from those types of responses.

As it turns out, the degree to which students grasp a concept can be *reliably* inferred only when they can somehow apply the concept in an authentic context. In other words, students cannot reasonably claim to understand what they cannot demonstrate. No one can become a world-class chef simply by attending lectures, however well delivered. At some point, the student chef must get into the kitchen and cook something. This isn't news, really. Back in 270 B.C., Sophocles said, "We learn by doing. That is the thing. For though you think you know it, you have no certainty until you try."

Undoubtedly, explanation and logic are important aspects of teaching any subject well, but they are insufficient by themselves to move most students' understanding of a topic beyond the naive level of simply recalling facts to the sophisticated level of using the knowledge to solve real problems.

So the questions for teachers are: How is understanding best measured? What kinds of learning experiences will move students down the continuum of understanding? Is there a feasible way to provide these experiences in the traditional classroom?

Building a model is one of the requirements of the design project. Credit: Edutopia

Elements of Worthwhile Projects

Teachers in the vocational fields and the arts have long understood that mastery of knowledge and skills requires students to create

products and performances. In any subject, when the product or performance students create is their solution to a real-world problem, the results can be powerful. For example, at Mountlake Terrace High School, some of my calculus students were also enrolled in a technology class in which they designed, built, and raced an electric car against college students, setting speed records as they went. I was impressed by the depth of technical knowledge they were gaining and by their evident excitement for learning. Their teacher posed a simple problem: "How can we build a car powered by electricity?" and this evolved into "How can we make the car go faster?"

The course curriculum was defined by knowledge and skills required to answer those questions, so the material had meaning for the students and they were motivated to learn. They began to view all their classes as potential sources of information to help them solve their car-building problem. Now they wanted to know how to apply calculus to determine the maximum speed at which they could navigate the tight turns on a race track. This was messy, authentic problem solving at its best!

Here, in these applied-learning projects, was an answer to the kind of learning experience students need in order to achieve true understanding of concepts. Observing the experts of these teaching strategies -- vocational and arts teachers -- I discovered that a worthwhile project has three key elements:
1. Students must be engaged in finding a solution to a genuine problem -- the type encountered by adults in the workplace, community, or home;
2. The problem must have an audience for student work other than the teacher. Ideally, the audience is someone who benefits from students' work; and
3. The problem cannot be optimally solved without correct application of academic knowledge and skills appropriate to the grade level or course. For example, my geometry students could not effectively solve the theater-seating problem without correctly applying the arc length formula.

- Applied learning typically involves students in creating a product or service, a system improvement, or an event. Here are some examples of these types of powerful learning experiences:
- A high school civics class organized and publicized a debate for its community between candidates running for the local school board. The students researched issues and mediated the panel discussion, which was featured on the local TV news.
- Two sixth-grade classes curated a cross-cultural art exhibit on "identity" at the city's art museum. They researched artwork, selected pieces, designed the exhibit, and wrote the wall text and object labels.
- A high school biology class carefully mapped the foliage overhang of a local river, using computers and sophisticated software purchased with a grant. Their findings are being used by researchers at one of the state's universities.
- A third-grade class organized a Young Author's Conference for community youth. Professional authors and storytellers provided workshops and entertainment.
- A middle school English class selected and recorded a set of books-on-tape for the children's department of the local public library.
- A high school business class grew herbs, and bottled, marketed, and sold organic salad dressing to grocery stores across the city. Profits were used to buy equipment, increase sales, and manage the business.
- A high school health class developed a home fire-safety program for their community in collaboration with the local fire department. Students created a safety information brochure, provided demonstrations on emergency procedures, and installed smoke detectors.

Work With the Big Questions

The purpose of applied-learning projects is to deepen students' understanding of fundamental course concepts and should therefore arise from a question central to the curriculum for a particular course or grade level. The project becomes the students' way to answer the question for themselves and make the resulting understanding stick because they have created something by using their new knowledge.

The projects listed above, for example, involved students in actively answering such questions as: What can you do if you're unhappy with some aspect of government? What does "local control" mean -- what are its benefits and drawbacks? What makes a good art exhibit? What ideas do different cultures share about the essential elements of selfhood? What is the scientific method? What effect, if any, does the shadow caused by overhanging foliage have on the plant and animal life in a river? What kinds of problems cannot be solved without the aid of technology? Why are stories important to a culture? What great stories survived for centuries through oral telling only? What is healthful food? What is involved in owning and operating a business? What is effective marketing? What can we do to prepare for an emergency? How can we make our homes and communities safer places to live?

Other Benefits of Applied Learning

For students, having an audience other than the teacher is a powerful motivator to produce work of the highest possible quality. Students become concerned about creating the best product or performance they can when the stakes are high -- when there is an audience to entertain, paying customers to satisfy, families relying on the accuracy of their information to keep themselves safe, and so on. They care about the work and tend to take it upon themselves to revise and edit it in a way they rarely do for traditional classroom assignments. The external audience also gives students a way to celebrate and value their work in a way that a single grade from a teacher cannot.

Another important result of applied learning is the opportunity the problem-solving process provides students to learn and improve life skills. These include self direction, managing complex projects, collaboration and teamwork, information gathering, and clear communication. Applied learning blurs the distinction between schoolwork and life outside the classroom, blending academic rigor with real-life relevance.

How to Make it Happen in Your Class

Once convinced of the merits of the applied-learning approach, most teachers face two pressing issues before they can start: where to find good ideas for projects and how to fit projects into an already crowded curriculum.

Students present their designs to local architects as a culminating event. Credit:

There are several sources for project ideas, many to be found on Web sites relating to project-based learning. Some problems in textbooks can be made more rigorous or relevant by incorporating real-life elements, by reworking the problem statement to allow for a variety of possible solutions, or by requiring an end-product to be presented to an audience or assessed by community members. Some projects suggest themselves from one's own experience, hobbies, or passions.

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Another excellent project resource is community professionals. They can help develop the key elements of an authentic task and assist with project assessment. Likewise, brainstorming with a colleague from another discipline can yield surprisingly good ideas, especially when the disciplines are not obviously related. Here the idea is to think of problems that require both disciplines to solve (for example, determining slopes on contour maps utilizes both algebra and geography). Access to technology, sophisticated software, or scientific equipment can yield a number of academically rigorous projects. Service learning is also a good source, because students are often highly motivated by making a contribution to their community.

With regard to making room in the curriculum for projects, this instructional approach probably won't work if it is viewed as one more thing to squeeze in. It is best approached as an alternative way to deliver instruction. Teaching for understanding requires a leaner curriculum to allow time to develop ideas more deeply. As difficult as it is, you must choose what is most important to teach, since you cannot possibly teach every concept to the level at which it is grasped well enough to be applied.

To make these choices you must consider several factors: the information students are held accountable for on high-stakes tests, the minimal depth of conceptual understanding they need in order to continue deepening their understanding in a subsequent course or grade level, and the most significant ideas underlying the course content. You should familiarize yourself with standardized tests, know the curriculum of the grade-level or content-area courses directly below and above that which you teach, and work to understand your curriculum as deeply as you can. This process is challenging but invaluable to effective teaching, and it puts curricular decisions on a sound basis.

Initially, at least, applied learning is a more demanding way to teach. But it is also infinitely more rewarding. The hard work of teaching no longer feels futile, since students leave your class retaining the most important ideas and having clearly improved their problem-solving, reasoning, and other life skills. Teachers who use applied-learning techniques don't need to work so hard to motivate students since the curriculum is no longer abstract, meaningless, and disconnected from their experience. Attendance increases, the quality of student work vastly improves, and failure rates and discipline problems decrease significantly, if not altogether, as students perceive value in what they're being asked to do. They feel respected, become engrossed in problem solving, and find compelling reasons to keep coming to class and applying themselves to learning.

Editor's Note: Educational consultant Eeva Reeder (/eeva-reeder) passed away in August of 2010 at the age of 53. We are grateful for her many contributions to the field of project-based learning and to Edutopia, and she is greatly missed.

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