Are We Educating or Training?

¿Estamos educando o entrenando?

Éduquer ou entraîner?

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Over the past 50 years, the United States has been the global leader in the development of advanced technologies, and this propensity for innovation has become an important part of the American cultural identity. There are, of course, multiple factors that have led to America’s technological dominance in the world. For one, the United States received talent from all over the world in the wave of immigration that followed World War II. However, many claim that the source of this success is inherent in the post-secondary educational system, which encourages creative thinking and values individual ideas (Kamenetz, 2011), and that despite the recent advances by China and India in graduating more scientists and engineers, Asia still looks to the U.S. for educational models to emulate (Kim, 2005). However, Asian governments continue to increase their investments in research and development, and in education, while at the same time the U.S. is systematically decreasing its funding of pure research and education. This leaves many wondering if the U.S. is losing its innovation edge (Segal, 2004). I want to look specifically at the situation in post-secondary education: are we really teaching our science and engineering students to think creatively?

I teach physics at the University of North Carolina Charlotte, and I observe that (especially at introductory and intermediate course levels), students are so constrained by the circumstances of the system that they do not feel free to think creatively. For example, during lecture, it often happens that when I present more than one approach to solving a problem, someone will inevitably ask “which way will we need to do it for the test?” Perhaps because of recent U.S. education policies, many students have, through their grade school experiences, come to see the classroom as a
training ground for tests. But I think there are more immediate concerns that prevent students from engaging in lateral thinking. A misunderstanding in grading could make the difference between an 89% and a 90%, which is the difference between an A and a B, which can mean the loss of a badly needed fellowship. Students don't want to take such risks, but unfortunately creativity often requires the risk to think differently. With young people continuing to bear the brunt of the ongoing recession, I believe that financial stresses put a tremendous strain on students' ability to work creatively.

A college degree has become the necessary training for most entry-level jobs; by 2018, it has been forecast that 63% of all jobs will require some form of post-secondary education (Carnevale, Smith, & Strohl, 2011). It follows that an important role of the university is to impart the skills necessary to prepare a suitable workforce for a growing economy. From this view, universities are a type of vocational training: a means to prepare workers for the job market by teaching them applicable skills. Since it is presumed that universities are specifically intended for those who seek to cultivate critical thinking and problem-solving skills, I ask: How, exactly, are these skills taught?

Here I want to draw on my somewhat unique experience as both art student and science teacher at UNC Charlotte. I have come to believe that fine arts students are better trained to creatively problem-solve than physics students, because of how studio classes are structured to encourage students to find their own solutions to assigned problems.

In an introductory studio class, the students are presented with a problem: an object they must make within certain parameters. For example, a typical introductory ceramics assignment might be to construct an object out of clay that is at least 15 inches high, composed of 10 hand-built geometrical shapes, while containing at least 3 different surface textures, and of course, and most importantly, it must be aesthetically pleasing. The students have 6 hours per week of supervised studio time during which to work on the problem and develop their ideas.

In contrast, a typical introductory physics class has 100 students and 3 hours per week of lecture time with little instructor interaction. The students are given textbook problems to solve and are shown how to do them step by step via example problems, and they learn to solve problems algorithmically. The course is normally fast paced—there are many topics that are to be covered in an introductory physics course—but many of the students come in having never seen physics in high school and difficulties with math, so many don't have enough time for a thorough understanding of the topics.

Our university has recently restructured the introductory courses such that the 3 hours per week is divided between lecture time with the professor and recitation time with a teaching assistant. (A recitation is a guided problem-solving session, usually led by a teaching assistant with no more than 30 students in each session.) While this restructuring gives students much needed small-class recitation sessions, it does so at the cost of lecture time (reduced to 1.5 hours per week) and at the cost of contact hours with the professor; and although it gives students incentive to spend more time on the
material outside of class, many feel at a loss without guidance. Studio art courses, in contrast, give students 6 hours per week of contact time with the instructor.

In physics courses, students can learn the algorithm of how to solve the general problem, and apply it in a compartmentalized manner without the need to ask any questions that are beyond the scope of a very narrow curriculum. Guided problem solving with individual attention from the instructor not only tailors the curriculum to help students grasp concepts from their unique point of view, but also helps challenge students to push their boundaries.

Smaller courses with more contact hours also allow instructors to make more accurate assessments of the student. Here is another interesting contrast between the way science and art are taught. While a score on a test or on a computer-based homework assignment is ostensibly a quantitative measure of the student’s mastery level, it often doesn’t accurately reflect the student’s knowledge. A student could have test anxiety, or could be having a bad day, despite having been able to solve similar problems the day before. The student could know how to navigate multiple choice tests without understanding the underlying concepts. The student could have someone else solve the problems to their computer-based homework assignment. Without a dialogue with the student, it’s impossible to assess their ability to apply the knowledge. Such a dialogue, even in the form of long-answer test questions, is not feasible unless the class size is small. The result of this dialogue is a more qualitative assessment, but one that may be more accurate. In the art classroom, the assessment process is by means of a critique, in which all students participate. It is interesting to note that putting the students final product up to this type of scrutiny clearly separates the successful projects from the mediocre ones, and though I have no knowledge of other students’ grades in the classroom, by the end of the critique it is quite evident who has received the A grades.

There are institutions that structure their physics classes with fewer students and more instructor contact hours. The introductory physics courses at UNC Chapel Hill include two laboratory hours per week as well as 3 hours of lecture. Their version of the introductory physics course for physicists and engineers also includes one hour of recitation per week on top of the three hours of lecture and two hours of lab. At MIT, the introductory physics classes are focused on group problem solving, and there are 6 hours of class time per week.

There is little doubt that small-class problem-centered learning is probably the most effective way to learn science, critical thinking, and problem solving skills, but the political and economic reality is that there will never be the necessary resources for smaller and longer classes as the demand for college education increases.

Perhaps this situation should be remedied if the U.S. wants to continue to train the top scientists and engineers. But perhaps, with the growth in number and variety of college choices available to students, one individual institution does not need such lofty aspirations if it is not willing or able to expend the resources necessary to achieve them. There are concrete needs that a regional institution must fulfill that still are within means of limited resources.

Specifically, what, exactly, do we want non-physics majors to get out of a physics class? For the students who are seeking a college degree to fulfill skill requirements,
there is a compartmentalized set of applied knowledge that they may need to know to better practice their profession. An architect may need a good understanding of static equilibrium. Someone working in the health sciences may need to have a sense of the forces an emergency room patient has experienced in an automobile accident.

So, if the assimilation of information is our purpose, it then begs the question, what, exactly, is so terrible about rote learning? Learning to solve problems algorithmically is a form of rote learning, assimilating the knowledge of how to approach a certain class of problems. Humanity has acquired a large amount of base knowledge that is needed to participate in society and to build new knowledge. Rote memorization was once a fundamental part of grade school curricula, but it fell out of favour in educational theory long ago. Despite this, there are still many strong defenders of rote memorization in schools (Beran, 2004; Snider, 2011), claiming that memorizing poems, for example, lays a strong framework from which children learn vocabulary among other advantages. Without entering into any discussions about cognition, it is safe to say that rote learning remains the easiest (fastest and least resource intensive) way to assimilate data.

Progressive trends in education and developments in psychology and pedagogy moved educators away from rote learning methods (also known as ‘drill and kill’), yet institutions don’t fully commit to what it takes to really learn to think critically and to make scientific decisions. I cannot propose a solution because I am not convinced that any truly student-centered teaching methods could be implemented without the resources needed to facilitate guided concept discovery (namely, more individual interaction with the instructor). The current learning environment at most universities is student-centered in only one sense: students are given some power over the structure of their education through evaluation feedback. Regrettably, their feedback is not part of the learning process, but is rather a rating and review of the teaching services rendered. The result is that the educators end up catering to “entertain” the students. I believe this is counter-productive because the reality is that the subject matter of an introductory physics classical mechanics course is going to be dry. There are ways to insert excitement into kinematics and dynamics: perhaps with a dramatic car crash story (a real-life example), or with a visual demonstration (computer simulations in particular help students see relationships between variables). One has to motivate and prepare the student to endure the dry parts. However, while such diversions are useful to maintain the students’ attention, I’m not sure how much these presentation enhancements really help with understanding the underlying physical model—the unembellished concept, which is the part that is dull for most students. In an ideal world, however, the underlying physical models we teach become part of a framework for the student’s imagination. Such a worldview transformation is not trivial—it requires instructor interaction and time to think and imagine. Creativity requires time—but not in the same way that arriving at a destination requires time—it’s not the type of time that can be shortened by speed or short cuts. Time itself is an ingredient for creativity, in the same way that clay is an ingredient for sculpting. If institutions cannot set up a framework in which instructors can spend time with individual students, then why not be honest about our educational goals and reach
them succinctly by fully embracing rote methods? The worry is, understandable, that these students will just memorize what they need to know, and compartmentalize that knowledge to the very limited application of passing the exam. The political reality is that the resources necessary to teach critical thinking and problem solving skills will probably never be allocated to introductory physics courses at most conventional university institutions, much less to introductory physics for non-majors. The pedagogical reality is that our current methods, despite useful enhancements such as interactive computer-based teaching aids, already amount to rote memorization — as this is what most students end up doing to make it through the crowded fast-paced course and as instructors in the current institutional framework, it is our duty to help them make it through the course. The hope is that the memorized information will form a foundation on which to construct ideas, or at the very least, to perform basic tasks in a high tech workplace. The other hope is that when this knowledge is passed on, even if by necessity through “drill and kill” methods, that teachers not ever lose sight of what science really is. Students must be reminded that science is not a prescribed set of laws; rather, the laws they learn are the fruits of a creative quest to understand nature, and science is the method by which this understanding was reached. It is a systematic method by which to organize one’s observations into discernible patterns. Science sheds light onto dark superstitions, and this has allowed humanity a degree of control over its own destiny. Organizing our observations of disease, for example, has led to theories that have resulted in prevention and cures. Science as a way of thinking has given us the clearest window by which to view the world. Maintaining a view of this bigger picture is an especially important concern in the teaching of science. The act of memorizing a poem does not distort one’s understanding of poetry. On the other hand, learning science by rote empties the knowledge of the context in which it was discovered, which can distort one’s understanding of the process of discovery.

References

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