PEER-LED TEAM LEARNING SUSTAINABILITY

THE ROLE OF THE TEACHING AND LEARNING ENVIRONMENT IN CONCEPT LEARNING IN THE SCIENCES

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We often focus on curriculum materials as the most important choice to be made when designing a course, but another important factor must be considered as well: the role of the environment in which the course is taught. A large lecture hall with hundreds of chairs bolted to the floor facing a stage may be an efficient and cost-effective way of assembling large numbers of students into the smallest possible space, but it is hardly a desirable environment for teaching a science course that is based on constructivist principles. Thus, in this article, we consider the nature of the learner and how that consideration allows us to draw conclusions about the ideal learning environment.

What is the Nature of the Learner?

Today's college students are different from students in the past. For all but the youngest of us who are teaching science courses, we have to break free from thinking, "What would I have thought was the best way to teach this?" and instead ask, "What is the best way to teach this to today's students?" The majority of this year's entering traditional students were born in 1991, and thus they grew up with computers and the Internet, and cell phones became ubiquitous by the time they were 10 years old.

One thing that has changed in college students is that they now routinely multitask, engaging in other activities at the same time that they do academic reading [1]. This can have an adverse effect on their ability to comprehend what they read, decreasing their study efficiency [2]. Ramaley and Zia (2005) described the current generation as "experiential, engaged, and constantly connected, with a strong need for immediacy." [3]. These characteristics are suggestive that a classroom with a heavy emphasis on lecture is very contrary to students' lives outside of the classroom, which features a great deal of environmental stimulus from multiple sources.

Another major difference in today's students is that they are more intelligent than students from previous generations. This phenomenon, known as the Flynn effect, is a conclusion that can be drawn from data showing that intelligence quotient (IQ) test scores are rising at a rate of about 3 IQ points per decade [4]. James Flynn, the man for whom the effect is named, believes that today's society demands that an individual must use abstract concepts more now than before because of the increasing complexity of the environment, and since this type of thinking ability is tested by IQ tests, its increase is what is being measured [5].

A third difference in today's students is that they are performing more poorly on tests of scientific reasoning [6]. This is probably a result of an increasing emphasis in the schools on the three Rs and a corresponding decrease in hands-on science being taught in the classroom, as well as a decrease in children's overall physical experiences with nature outside of the classroom.

The discussion thus far may lead one to believe that today's students are radically different from previous generations, but that is not the case. The changes in students are indeed significant, but the fundamental processes by which humans learn are invariant and unchanged from generation to generation. The model of the learner postulated by Lev Vygotsky, an early-twentieth-century Belarusian psychologist, describes these fundamental processes. There are three key ideas relevant to college science courses: (1) knowledge is constructed in the mind of the learner, (2) learning can lead development, and (3) development cannot be separated from its social context [7,8].

Vygotsky also introduced another idea central to understanding how students learn, the zone of proximal development, or ZPD. Vygotsky defined the ZPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers." (p. 86) [7]. Vygotsky advocated that instruction should target this zone, where students are working problems slightly beyond their present capabilities under guidance from someone who is more capable.

Another invariant component of learning is the process known as self-regulation. This has three features: (1) use of self-regulated learning strategies to achieve academic goals, (2) being responsive to feedback by reacting to it and changing behavior and strategies, as necessary, and (3) making an effort, being vigilant, and dedicating sufficient preparation time [9]. Students must be willing to self regulate if they are to be successful learners. Science instructors can encourage self regulation among students by designing the environment to provoke disequilibrium and by providing hints and leading questions to assist students in knowledge construction [10].

This section asks, "What is the nature of the learner?" We have seen that today's students are different from the students of prior generations. They are used to a very simulative environment in which they frequently work on two or more tasks at the same time, they are very intelligent, and they tend to be less likely to have actual physical experiences with manipulation of the natural world. We have also seen that the learning *process* is the same for this generation as with past generations. Students use the process of self regulation to mediate construction of knowledge, and they learn when challenged by problems that are slightly beyond their current problem-solving capabilities.

<u>What is the Ideal Learning Environment?</u>

Now that we have established a model of the learner, we can use that model to derive the ideal learning environment. It is both intuitive and a conclusion that can be drawn from the research literature that the definitive ideal environment is one-on-one tutoring [11]. But this question is actually asking about the ideal environment for group instruction because long-term one-on-one instruction from a well-qualified instructor is prohibitively expensive except in specialized cases.

An experimentally-proven model of instruction that accounts for all of invariant processes of learning has been constructed by Philip Adey and Michael Shayer of Kings College in London. This model features a four-step process: (1) concrete preparation to assure that students are sufficiently grounded so that they can move beyond their present level of thinking ability, (2) construction of new and/or improved knowledge through instructor-mediated activities, (3) metacognitive strategies to lead to an understanding of the thinking processes used, and (4) bridging activities that help students link new knowledge to old [12]. We will now consider each of these four steps in more detail.

Concrete preparation is needed to assure that students are sufficiently primed for knowledge-construction activities. This can best be accomplished by a process known as deliberate practice, which is structured activity that has the explicit goal of improvement of performance [13]. Gaining skill is not simply a matter of obtaining additional experience, but rather, that experience must be specifically designed to overcome weaknesses, and it must be monitored to identify cues to improve performance further.

Construction of new and/or improved knowledge occurs more readily in courses that feature interactive engagement than those taught by expository methods. When the two curriculum approaches were compared across a large number of introductory physics courses at the high school, college, and university levels, Hake found that the best-taught expository course was essentially equivalent to the most poorly-taught interactive engagement course, when measuring student content knowledge gains [14]. Interactive engagement is defined by Hake as "methods as those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors." (p. 65).

Metacognition is making explicit the thinking *process* itself. It includes things such as knowledge about how learning occurs, knowledge about how to improve learning, making judgments about whether you are correctly approaching the solution to a problem, determining whether to take a new approach to solving a problem, deciding whether to keep working on a difficult problem or to give up, and evaluating how well you understand what you are reading in a textbook [15]. Metacognition is particularly important in science education in helping students learn scientific reasoning skills. For example, if a problem is solved with a proportional reasoning strategy, instructors need to make explicit that the problem-solving process involves proportional reasoning. When students learn to become aware of reasoning skills, they are more likely to use them when approaching novel problems.

Bridging is connecting new knowledge to old. Curricula that incorporate bridging typically ask students to apply strategies that were just learned to other school contexts or contexts outside of school [16]. Bridging is needed because students need to re-organize the structural relationships that comprise their knowledge when one component of that knowledge is changed. For example, if you learn something significantly new about dogs, you need to re-organize your knowledge of household pets, wolves, coyotes, pack animals, etc., all of which are likely to be linked in some way to your "dog" concept.

This section asks, "What is the ideal learning environment?" For group instruction, we can conclude that the essential components include concrete preparation via deliberate practice, construction via interactive engagement methods such as Peer-Led Team Learning, metacognition activities to improve scientific reasoning skills, and bridging activities to help students organize their knowledge.

How Can This Teaching and Learning Model be Applied in the Science Classroom?

Turning the model of the ideal learning environment into practice is the primary challenge of individual instructors. There are many ways to do so and many ways to approximate the ideal model when you have to work with limited resources. Keep in mind that these are just some of the myriad of possibilities.

Concrete preparation can be accomplished primarily by assignment of homework sets. Traditional textbook-based homework can be effective if your textbook has problems that you find relevant to your learning goals. You can also write your own homework sets. Many textbooks are supported with study guides that have problems that could be assigned. Online homework systems that deliver a unique problem to each student are also increasing in quality and becoming more readily available.

To optimize students' knowledge construction process, you should try to minimize the amount of time you spend delivering expository lectures. Replace the time that you used to lecture with interactive engagement, active learning approaches.

You can bring the building of students' metacognitive strategies into your curriculum by explicitly explaining thinking strategies while demonstrating problem solving. Specifically point out those strategies that are commonly used in your discipline. Pay attention to the discussing of thinking when looking at textbooks in your next adoption cycle. If you use an active learning approach in your lecture or discussion section, have students think out loud when solving problems with a partner.

Bridging can be incorporated into your curriculum most simply by selecting homework questions that require the integration of old skills with newly-learned skills. These are often called "summary questions" in textbooks. Utilizing one of the many inquiry laboratory manuals currently available is also a good way to help students connect classroom learning with an authentic scientific experience. Finally, spiral curriculum methods that move from simple models early in the term to more sophisticated models as the term progresses provide excellent bridging opportunities.

A Model Classroom

The North Carolina State University Department of Physics has instituted a project called SCALE-UP that has, as one of its products, led to the development of studio classrooms (see http://www.ncsu.edu/PER/scaleup.html). A studio classroom is designed for active learning rather than lecturing. This provides a superior learning environment for students.

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