Learning by Simulations:
A New and Effective Pedagogical Approach
for Science, Engineering and Technology
Students in a Traditional Setting

Tukaram D. Dongale, Shivaji University, Kolhapur, India
Sarita S. Patil, Shivaji University, Kolhapur, India
Rajanish K. Kamat, Shivaji University, Kolhapur, India

ABSTRACT

Using a pedagogic case study in a traditional learning environment, in this paper, the authors demonstrate how an innovative yet practical computer-based simulation of a complex nano device was an effective tool that improved the learning outcomes of academically less-prepared Bachelor of Nanoscience students in an undergraduate engineering course in a rural university. The authors’ case study presented in this paper strongly suggests that innovations in content delivery, and adaptive learning such as via simulations, can transform what it means to educate students in the 21st century.

Keywords: Academically Underprepared Students, Computer-based Simulated Learning Environments, Intelligent Tutoring Systems, Memristors, Technology Enhanced Learning

INTRODUCTION: COMPUTER-BASED SIMULATIONS AS A POWERFUL LEARNING TOOL

Using a pedagogic case study in a traditional learning environment, we demonstrate how an innovative yet practical computer-based simulation of a complex nano device was an effective tool that improved the learning outcomes of academically less-prepared Bachelor of Nanoscience students in an undergraduate engineering course in a rural university.

University educators across the disciplines tend to find the teaching of complex ideas such as threshold concepts and technologies to undergraduates a daunting task. Students in all disciplines have to learn concepts that are fundamental to their discipline’s body of knowledge. Students need to have a correct and accurate understanding of these in order for core disciplinary knowledge to make sense to them. While such difficult to learn concepts are often very challenging, and troubling to students and faculty alike, they also act as a portal, as they open up whole new and

DOI: 10.4018/IJQAETE.2015040102
previously inaccessible ways of thinking, and providing students with ‘really useful knowledge’. This means that educators need to find better ways of teaching and learning to help students really ‘get’ and understand the knowledge that is core to their discipline (Meyer & Land, 2003).

If understanding key knowledge areas is problematic for the general population of students, than even more so for students who, through no fault of their own, find themselves academically underprepared for their undergraduate studies. The point is that with increased access to higher education, especially from social groups previously excluded for financial and geographic reasons, enrolment numbers have increased substantially, and with that the number of students ‘at-risk’ for academic success (Eijkman, 2004; Bernstein, 1981). Following Eijkman (2004) we define **academically underprepared students** as those sub-groups of students who are at-risk of academic failure as a result of prior, and poorer, educational experiences such as in less resourced village schools, homes and neighbourhoods that lack a culture of literacy and intellectual stimulation. These students, though on average just as potentially smart as their better-off urban counterparts, are likely to have a history of educational failure and are poorly prepared for post-school learning and therefore tend to have lower expectations and self-confidence (Eijkman, 2004; King, 2004). As Ender and Wilkie (2000) further suggest, underprepared students may have a negative self-concept with respect to their academic environment. Many universities and colleges in the rural hinterlands of low income countries have very high proportions of such academically underprepared student cohorts who often find complex concepts very difficult to learn. This is precisely the problem we faced in teaching the functions and properties of memristors as highly complex nano devices at our university, based in rural Maharashtra.

This case study, situated in a very tradition-bound higher education system, exposed a cohort of Nanoscience students – many of whom we classify as academically underprepared - to a digital simulation while another cohort, drawn from the same course and class, was subjected to the conventional chalk and talk method. The comparison clearly demonstrates the effectiveness of allowing such students to learn, hands-on, using a memristor simulation tool, based on a JAVA software platform.

We open with a brief overview of the use of computer-based simulations in higher education. The focus then shifts to the simulation tool we developed and trialed in this pilot experiment, namely the memristor, and a description of the comparative experimental research method we used to investigate its effectiveness in this pilot study.

The positive results of this comparative experiment are two-fold. First, it demonstrates that a simulation based teaching-learning methodology even with academically underprepared students long embedded in a traditional transmission-based pedagogical environment can significantly enhance their performance. Second, this novel approach to learning promotes student motivation and encourages active participation, which, while important to students generally, is even more so for academically underprepared students. Not surprisingly perhaps, we found that simulation based learning also stimulated curiosity in our students and promoted a shift from surface to deep learning.

### BACKGROUND: TECHNOLOGY ENHANCED LEARNING

Teachers have always used technology in their classrooms, from chalk and blackboards to TV and videos. However, with the proliferation of computers along with the trend towards ubiquitous computing, higher education has seen a significant shift to computer-based, or Technology-Enhanced Learning (TEL), especially in the last decade or so (Eijkman, 2008; Patil & Abraham, 2010). As pointed out by Patil and Abraham (2010:80) “The three most common modes of
Related Content

Web-Based Training: An Applicable Tool for Engineering Education
[www.igi-global.com/chapter/web-based-training/44736?camid=4v1a](www.igi-global.com/chapter/web-based-training/44736?camid=4v1a)

Learning by Simulations: A New and Effective Pedagogical Approach for Science, Engineering and Technology Students in a Traditional Setting
[www.igi-global.com/article/learning-by-simulations/134874?camid=4v1a](www.igi-global.com/article/learning-by-simulations/134874?camid=4v1a)
Evaluating Engineering Students’ Perceptions: The Impact of Team-Based Learning Practices in Engineering Education
www.igi-global.com/article/evaluating-engineering-students-perceptions/182861?camid=4v1a

SET Women and Careers: A Case Study of Senior Female Scientists in the UK
www.igi-global.com/chapter/set-women-careers/43210?camid=4v1a