STUDENT ISSUES

Today we depend on computers and the Internet to do our jobs, yet we have only begun to scratch the surface of using technology to improve education.[i,ii,iii] Rensselaer has made significant changes in the way engineering education is delivered that were detailed in the Boyer Commission document - REINVENTING UNDERGRADUATE EDUCATION: A Blueprint for America's Research Universities. Rensselaer has since garnered national awards (*the Hesburgh Award, the Boeing Educator of the Year, and the Pew Foundation Leadership Award*) that recognized the work we are doing to benefit technical education. Even with such advances, we still need to incorporate more practical examples, illustrative materials, and engaging hands-on activities that reach and motivate the diverse groups of today's students. [iv] We now have the potential to identify a student's learning style[v] and difficulties in grasping concepts, thus allowing us to deliver education in more effective ways.[vi] Educators need to provide supplemental hands-on components so that visual/tactile learners can garner an understanding of the material, while stronger students can explore activities in greater depth to maintain interest.[vii,viii] Even today's most successful courses, regardless of format, can take advantage of recent advances in cognitive science[ix], learning research[x], and educational technology to help address the following issues:

- ***Computer Savvy Students:*** When the concept of Studio was originally implemented, it dramatically reduced the number of in-class demonstrations which previously were hallmarks of the introductory courses at Rensselaer—predominantly due to space limitations. These were replaced, in part, by computer simulations that were innovative at the time and used an emerging technology which captured student's interest; but today's student has grown up with computers. Demonstrations and laboratories performed on computers fail to capture the students' interest as they once did. We hypothesize that because students spend so much of their time playing with computers as children, today's students are very savvy with software, but seem to be less aware of real-world phenomena.[xi]
- ***Attention Span:*** We have observed a diminished ability for students to stay focused and pay attention in class. Even the dramatically reduced "lecture" portion of our studio classes is less effective than it once was. It is well supported by educational research that humans retain perhaps 10% of what they hear someone else tell them, but retain as much as 90% of what they learn by doing.[xii]
- ***Demands on Students' Time:*** Student attention span and consciousness in class is also problematic due to the highly emphasized social aspect of the university environment (i.e. email, IM, etc.). Many of today's students seek a "college experience" composed of a vast number of extracurricular activities, not just instruction in academic subjects. Formal education is consuming a smaller percentage of their time. Additionally, project-based courses require a great deal of out-of-class team meeting time, often late at night.
- ***A Shortage of Hands-on Exploration:*** Pre-exposure to technical concepts is far less uniform among students from increasingly diverse educational and cultural backgrounds than it was a decade ago. Gone are the days when the majority of STEM-inclined students

were ham radio operators, played with Erector/LEGO sets and had tinkered extensively with electronic kits—or simply taken things apart. Variance in learning styles requires attention to individual talents and weaknesses.[xiii]

"Studio teaching" improved the quality of education at Rensselaer and has since been adopted, in various forms, by many other universities. However, after more than ten years we now need to make modifications that can better serve today's generation of students. We have identified the following specific opportunities for improvement:

- ***More Closely Couple Lectures with Hands-On Activities:*** Education research has made it clear that large-scale lectures, regardless of the quality of the instructor, are inefficient vehicles for learning. The lecture format gives the appearance of being cost-effective, yet students are learning little (if they attend). Small classes promote learning, but are cost-prohibitive in large enrollment courses associated with core introductory engineering education.[xiv] Studio does not eliminate the lecture portion of the class, yet a majority of students do not pay attention or retain much of what they hear in the lecture or during the homework review. Therefore, any part of the class where students merely sit and attempt to listen passively - will be less effective than when they are *actively engaged*.
- ***Make Better Use of Existing Facilities:*** Studio classrooms are often crowded, with 40 or more students, the professor, and two TAs occupying slightly over 1,000 square feet. Spaces to undertake hands-on activities are limited, so that some of the activities cannot be done comfortably in the allotted areas. The available laboratory equipment that can be used is also limited by other classes using the same rooms, requiring the equipment to be both frequently installed and removed. Since we must live with these limitations, the challenge for technical education is to *develop a novel, compact and portable means to allow for the hands-on learning* of concepts in minimal classroom spaces – while further *expanding the opportunities to experiment outside the classroom* as well.
- ***Extend the Time Available for Activity/Laboratory:*** In the studio format, the activity portion can last from 40 to 50 minutes. This is *insufficient time* for the students to do any sort of probing, meaningful experiments. Activities are therefore constrained to covering a few main points at a superficial level. Even so, the slower student teams struggle to finish the activities in the allotted time and often wind up missing the main points in an effort to complete the detailed steps in the activity instructions.
- ***Require Active Participation of ALL Students:*** Even when student teams are able to finish on time, we often find that some team members are content to passively watch and record data while the "alpha" team member handles the equipment and takes data. While working in a team is an important skill, *each student also needs individual practice* setting up equipment, taking data, and troubleshooting in order to reach his/her full potential as a technical professional.
- ***Overcome Equipment Limitations:*** Much of the hands-on equipment that is used in studio makes extensive use of wiring to connect the components of the experiments. The equipment and components are unwieldy, and *take up an inordinate amount of space* on a table top. Students using these set-ups have as little as a few inches of remaining space for

books, notebooks and writing space. In addition, the wire connections and limited space significantly interfere with the data taking process in many experiments, yielding results that are not fully consistent from the students' perspective with the principles being taught.

- ***Provide More Hands-On Equipment:*** Some of the activities (that do not use equipment) simply make use of outdated computer simulations or are entirely pencil-on-paper problems. These activities could greatly *benefit from physical experiments* that take advantage of Rensselaer's low-cost, signal acquisition, monitoring and control instrumentation/equipment (*Mobile Studio I/O Board*).

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