Chapter 8
Use of Living Systems to Teach Basic Engineering Concepts

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ABSTRACT

Engineering educators have typically used non-living systems or products to demonstrate engineering principles. Each traditional engineering discipline has its own products or processes that they use to demonstrate concepts and principles relevant to the discipline. In recent years engineering education has undergone major changes with a drive to incorporate sustainability and green engineering concepts into the curriculum. As such an innovative initiative has been undertaken to use a living system such as an aquarium to teach basic engineering principles. Activities and course content were developed for a freshman engineering class at Rowan University and the Cumberland County College and K-12 outreach for the New Jersey Academy for Aquatic Sciences. All developed materials are available on a dynamic website for rapid dissemination and adoption.

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INTRODUCTION

An aquarium is an exquisite combination of interacting systems which can be analyzed using multidisciplinary engineering principles. Children typically have personal aquariums for their pet fishes and visit some large aquarium as part of a school field trip or as part of their family outing. Movies such as Disney-Pixar's "*Finding Nemo*", *Epcot's Living Seas* also make tremendous impact on a young audience. While these activities apparently raise the knowledge base in terms of nature and the environment, children seldom make a connection to the engineering principles playing out in the maintenance of a natural, commercial or personal aquarium. Thus the idea of using an aquarium to promote engineering concepts for a wide audience is innovative and exciting. A creative initiative between the College of Engineering at Rowan University, Cumberland County College (CCC) and the New Jersey Academy of Aquatic Sciences (NJAAS) to enhance STEM (**S**cience, **T**echnology, **E**ngineering, **M**athematics) education at all levels has been undertaken by receiving support from the National Science Foundation. There is a growing realization among engineering faculty that a new vision for the education of engineers needs to evolve to keep this country at the forefront of technology. Science and engineering are essential for paving the way for America's future through *discovery, learning and innovation*[1]. A recent report[2] indicates that the United States lags behind the world in technological innovation because of its poor performance in teaching math and science. This eliminates many of the best and brightest schoolchildren from the ranks of future scientists and engineers. Many students who do undertake science and engineering studies in college are unprepared and drop out in frustration, while other potentially capable students never consider these subjects in the first place. In both cases, precious human and institutional resources are squandered. Enhanced engineering education in our K-12 classrooms can provide students at an earlier age with a more specific understanding of what a technical career entails.

The College of Engineering at Rowan University is always seeking innovative teaching methods to excite freshman engineering students about engineering design (Jahan, K., Hesketh, R. P., Schmalzel, J. L. & Marchese, A. J., 2001; Harvey, R., Johnson, F., Marchese, A. J., Newell, J. A., Ramachandran, R. P., & Sukumaran, B., 1999; Hesketh, R.P., Farrell, S., & Slater, C.S., 2003; Schmalzel, J. L., Marchese, A. J., Mariappan, J., & Mandayam, S., 1998; Hesketh, R. P., Jahan, K., & Marchese, A. J., 1997; Marchese, A. J., Newell, J., Ramachandran, R. P., Sukumaran, B., Schmalzel, J. L & Maraiappan, J. L., 1999; Jahan, K.., & Dusseau, R.A., 1998; Jahan, K., Marchese, A. J., Hesketh, R.P., Slater, C.S., Schmalzel, J.L., Chandrupatla, T.R., & Dusseau, R.A., 1998; Jahan, K., & Dusseau, R.A., 1998; Ramachandran R. P., Schmazel, J., & Mandayam, S., 1999; Marchese, A. J., Ramachandran, R. P., Hesketh, R., Schmalzel, J., & Newell, H. L., 2003; Farrell, S., Hesketh, R. P., Newell, J. A., & Slater, C. S., 2001). The aquarium project was selected to expose K-12 students/educators, freshman students in engineering at Rowan and CCC to basic science and engineering concepts. Students can easily be introduced to chemical, mechanical, electrical, civil and environmental principles such as mass and energy balances; fluid flow; work, energy, and efficiency; forces and levers; material strength and stresses; water quality and treatment; and electrical signal processing via this project. The aquarium theme also adds to the need for an understanding of biological systems, ecosystems, pollution and sustainable development. These are concepts that have been absent in typical traditional engineering courses.