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Integrated Engineering Curricula

Structured Summary – Integrated Engineering Curricula

Integrated curricula for first-year and sophomore courses have been developed and offered at several different institutions during the past 15–20 years. Integrated curricula are intended to help students build stronger links among different subjects that are encompassed within a particular integrated curriculum. Motivations for developing and offering integrated curricula include at least the following three reasons. First, student retention after both the first and second years of a four-year engineering program requires significant improvement. Second, comments from students suggest that they see few connections between their mathematics and science courses and their future careers in engineering. Third, engineering faculty indicate that students should be better able to apply introductory science and mathematics in their engineering courses. Based on three theoretical foundations: integrative and reductive educational goals, the science of learning, and efforts to improve diversity, integrated curricula should offer better preparation for further study and future engineering practice. Given the number and diversity of integrated curricula that have been offered, a study that attempted to synthesize existing findings and proposed directions for future study seemed appropriate.

The two primary questions that the study attempted to address were (1) What has been learned from the integrated curricula that have been implemented to date? and (2) Based on the work that has been accomplished, what appear to be profitable directions for future study? Before presenting its synthesis of the literature to address these two questions, the paper addressed the scope of integrated curricula to be included in the study.

Given the diversity of meaning that has been attached to integration in engineering education and the diversity of integrated programs that have been offered, the authors developed three criteria for selecting integrated curricula to be included in the study.

· Integrated curricula must encompass multiple disciplines and faculty members from multiple disciplines must collaborate in developing and implementing the curricula. A precise definition of an academic discipline is not offered, but the scope of an integrated curriculum would encompass at least all of engineering and most often, especially in integrated first-year curricula, extend beyond engineering to include mathematics and science and sometimes communications, humanities, and social sciences.

· Projects must report assessment data to ascertain the degree to which a project has affected one or more student outcomes. This criterion eliminated some potentially interesting integrated curricula from outside the United States. Lack of broader representation across the global community interested in engineering education was a serious concern for the authors, but evaluation of integrated curricula efforts absolutely required assessment data.

· Students in the program must be satisfying course requirements from multiple disciplines (e.g., engineering and physics).

Once the integrated curricula to be studied were identified, the authors attempted to find all of the publications related to these projects. Also, the authors found several papers that had synthesized results from study of multiple integrated curricula. The resulting bibliography should be a valuable resource for future researchers. The authors reviewed the papers and attempted to synthesize results across the reported research.

Analysis of integrated programs that have been offered to date has shown the following characteristics:

· Faculty development through which faculty members reflect upon and revise their perspectives on learning and teaching and which was not an initial goal of any integrated project may be the most significant long-term outcome.

· Systematic analysis of improvements in student outcomes is hampered by the diversity of assessment methods and data used by different programs, but trends show improvements in student outcomes across multiple projects.

· Design projects were used repeatedly to help students make connections among subjects, material, and applications. However, the nature of the design projects was and will be crucial to the success of the design projects in achieving this goal.

· Implementation of integrated curricula expanded use of cooperative learning and student teams, especially in design projects.

· Large-scale curricular change is complex, and faculty members and administrators often changed their model of how institutional change occurs as they move from through the change process.

Areas that were not adequately addressed across the spectrum of integrated curricular projects suggested directions for future research.

· More research is required to develop learning outcomes for integrative learning. Methods appropriate for assessing integrative learning outcomes must also be developed. Potential outcomes and assessment methodologies include concept map-based outcomes, outcomes involving integrated problems, outcomes involving design process, and outcomes associated with transfer of learning.

· Longitudinal studies may be necessary to evaluate differences in student performance related to integrative learning.

· Evaluative systems to look at alternative integrated curricular approaches are required. Faculty members at the Franklin W. Olin College of Engineering are implementing integrated course blocks with semester-long centerpiece projects. Potential metrics include student learning, retention, cost, and faculty time.

· Differences in metacognitive outcomes may be another approach to describing and assessing integrative learning.

· Long-term departmental and college changes related to development of integrated curriculum may be another potential research direction.

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