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Identifying and Mapping Pivotal Concepts and Critical Skills
Concept mapping a "Freshmore" Engineering Curriculum

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The Massachusetts Institute of Technology (MIT) has collaborated with the government of Singapore to create a new university, the Singapore University of Technology and Design (SUTD); the first SUTD students began classes in May 2012. MIT contributed to the development of SUTD's undergraduate curriculum, and, as part of that effort, MIT's Teaching and Learning Laboratory (TLL) identified pivotal concepts and critical skills from what is called SUTD's "freshmore year," which encompasses the first three semesters of the students' course of study. The goal of identifying pivotal concepts and critical skills was to see how they supported learning throughout the SUTD curriculum, generally, and, specifically, how they were connected across disciplines.

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Using a "constructive alignment" process advocated by John Biggs and Catherine Tang, who recommend beginning the construction of a curriculum with intended learning outcomes, and a process for "clarifying content priorities" advocated by Grant Wiggins and Jay McTighe, we began the difficult task of identifying pivotal concepts and critical skills. We were fortunate in that faculty and instructional staff from MIT had already begun the process of defining SUTD's curriculum. Most of the courses in the freshmore year already had a number of intended learning outcomes associated with them. By considering what concepts and skills would support these intended learning outcomes, concepts considered to be truly interdisciplinary according to the literature on integrated curricula, and concepts documented to be problematic for students in the literature on student misconceptions and misunderstandings, we began to refine our list of pivotal concepts and critical skills.

In the end, a concept or skill was identified as pivotal when it satisfied one of two criteria: (1) it was prerequisite for multiple concepts that would be taught in upper-level courses; or (2) it was pervasive across disciplines.

The result of this process was an Engineering Curriculum Map (the "Map"), which diagrams, for both faculty and students, the crucial ideas and capabilities SUTD students should master in their first three semesters. The Map also visually represents the interdisciplinary connections among concepts that may otherwise appear to be from disparate disciplines (e.g., physics, math, biology, chemistry).

After the Map was developed, it guided the creation of a set of 15-minute videos narrated by MIT faculty and graduate students, called "concept vignettes," which contribute to the curricular materials available to SUTD. These videos teach pivotal concepts and critical skills by utilizing animations, visualizations, and/or demonstrations.

The intention of the Map and concept vignettes is to provide students with a coherent educational framework by bringing pivotal concepts to the forefront of the learning experience. We hope the Engineering Curriculum Map will be of interest to curriculum developers, department chairs, and professors of both introductory and more advanced engineering courses. By highlighting pivotal concepts that reappear throughout the curriculum, our goal is to help instructors and faculty provide additional opportunities for students to revisit these concepts within their courses. ■