Describing Results from the Classification Scheme for First Year Engineering Courses using Mathematical Modeling Techniques

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Introduction:

The *First-Year Engineering Course Classification Scheme* is a taxonomy of all objectives that could be found in general Introduction to Engineering courses that was developed through a National Science Foundation grant [1]. Initially, the purpose of the scheme was to allow instructors to describe the content of their courses using a common tool.

Despite the taxonomy being complete, investigation into precise **relationships between different engineering courses** and connections to **instructional variables such as assessment** remained. Initial attempts of comparisons took the form of radar plots where fundamental differences are visually apparent between courses. On the other hand, incorporating assessment seemed to be a lofty, but certainly important, component of interest to first-year faculty. The advantages of formally defining such differences and relationships between the outcomes (Figure 1), assessment, and performance objectives prompted a study to develop a mathematical model in order to facilitate these investigations.

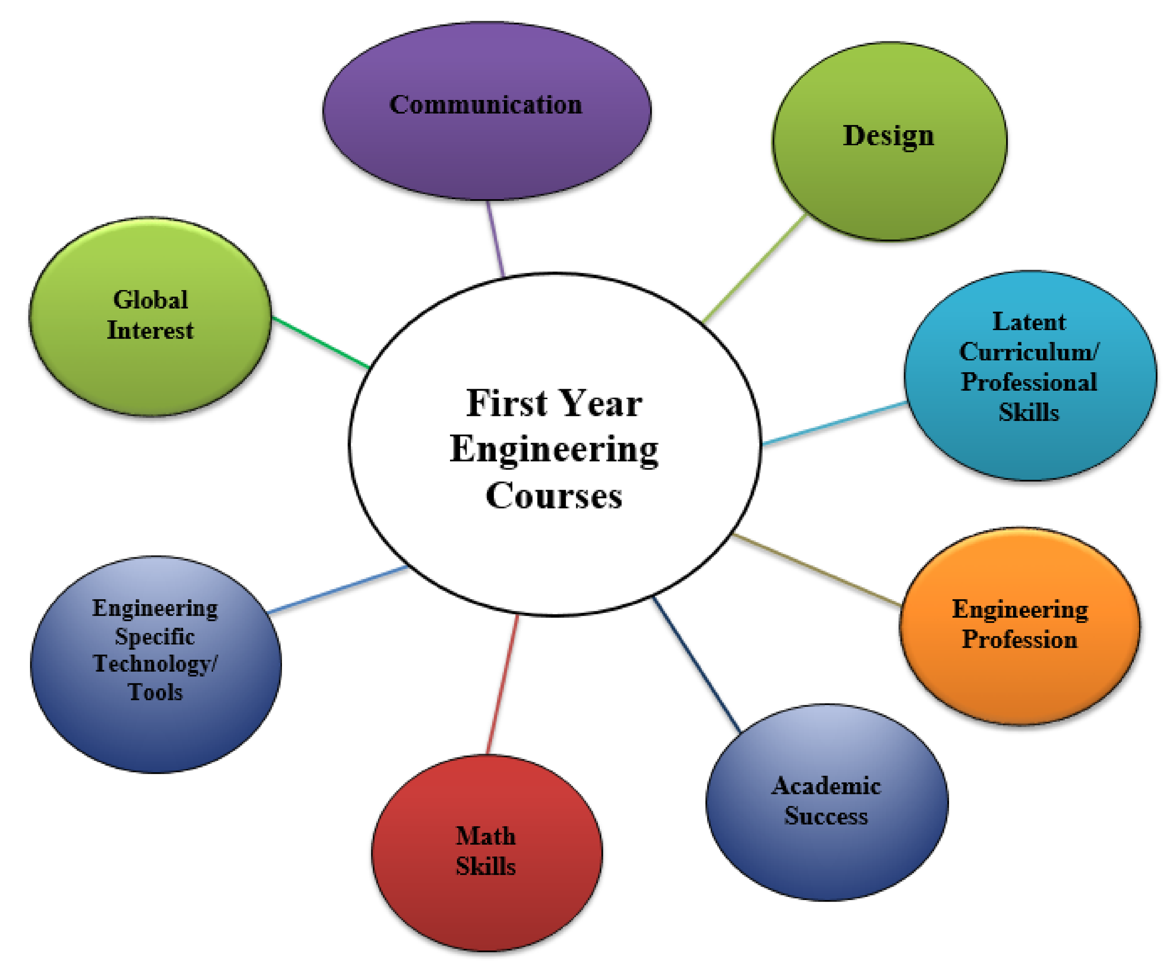
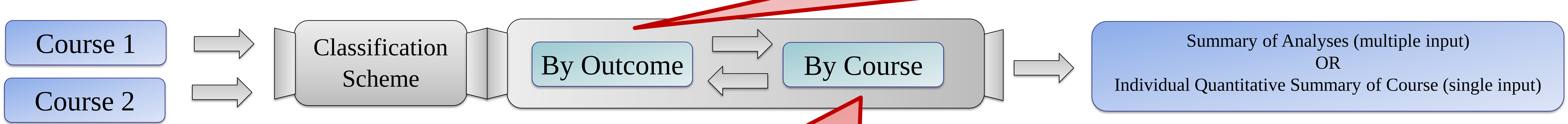


Figure 1: Top Level of the Scheme (Main Outcomes) [1]

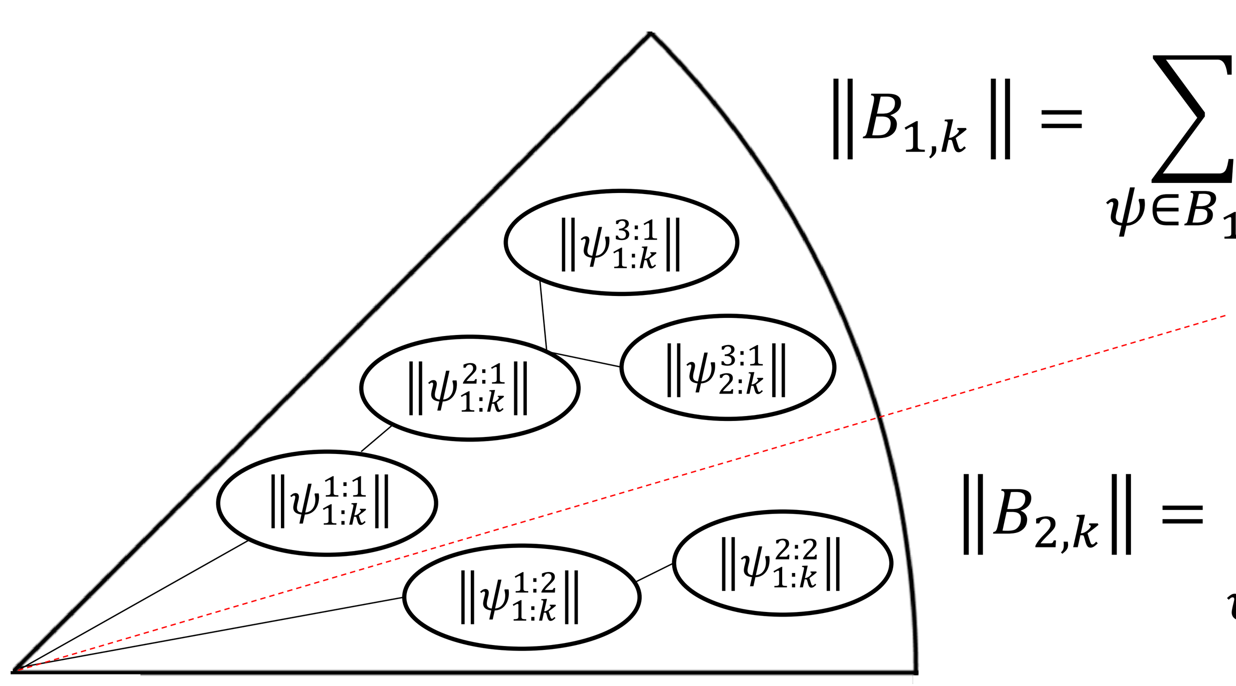
Methodology:

The principled approach of developing a successful model is based on methods described by Dym and Carson & Cobelli [2,3]. Abstract mathematics led the creation of this model, particularly set, graph, and group theory. The development of a general theory concerning application to this taxonomy is invaluable to the generalization to other engineering courses – or any course for that matter.

By Outcome Analysis involves a *branch plot*, Figure 2. One arbitrary sector is shown with hypothetical outcomes plotted in formations termed as *branches*, where the i^{th} branch for main outcome k is $B_{i,k}$. The value attributed to each ψ is denoted as $\|\psi_{x:k}^{n:b}\|$ for the x^{th} outcome on branch b on level n of the scheme for outcome k. The *directional sum* is then given by $B_{b,k} = \sum_{\psi \in B_{b,k}} \|\psi_{x:k}^{n:b}\|$.



By Course Analysis provides a broad summary of a course using a radar chart (Fig 3). With polar coordinates, a vertex, P_k, is determined by the sum of *all* directional sums for outcome k, where θ_k is the angle subtended by the radius of k from the positive x axis – building on By Outcome Analysis.



$$\|B_{1,k}\| = \sum_{\psi \in B_{1,k}} \|\psi\|$$

$$\|B_{2,k}\| = \sum_{\psi \in B_{2,k}} \|\psi\|$$

Figure 2: Branch Plot of Sector for Arbitrary Outcome k

$$P_k = \left(\sum_{all\ r} B_{r,k}\, ,\theta_k \right)$$

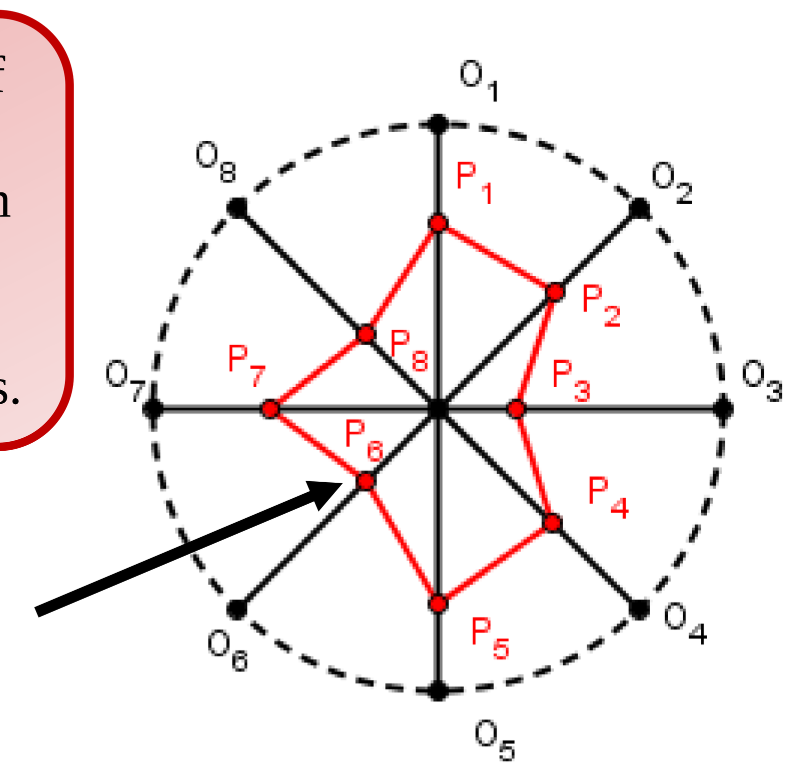


Figure 3: Radar Plot of an Arbitrary Course

Branch Plot displays *specific* gaps in coverage

Radar Chart displays *general* gaps in coverage

Future Work:

The scheme will need to be edited in order to reduce the variability when a course is classified multiple times. Assigning an appropriate system to quantify assessments and performances objectives such that there is a nontrivial connection between them in the context of the model is also in development. It is apparent that more data is needed from diverse sources to not only test the scheme, but also to perform any meaning preliminary testing of the mathematical model.

Conclusion:

Since the content of first year engineering courses is typically a combination of the instructor's preferences, program learning outcomes, and accreditation requirements, a more formalized method of comparing courses is a necessity. In addition, being able to determine best assessment practices and performance objectives in the context of curricula development and revision via some model is desirable.

We have proposed a convenient and programmable method of succinctly summarizing a course's content, performance objectives, and modes of assessment, both top down and bottom up, that can serve as a welcome tool for the first year engineering community. We expect this model to be useful in accurately awarding transfer credit, informing curriculum development, and strengthening best assessment practices.

References:

1. Reid, Kenneth, David Reeping. (2014, June). A classification scheme for "Introduction to Engineering" courses: defining first-year courses based on descriptions, outcomes, and assessment. Presented at the American Society for Engineering Education Annual Conference & Exposition. Indianapolis, IN (1-11). Washington DC: American Society for Engineering Education
2. Dym, Clive L. "Principles of Mathematical Modeling." Principles of Mathematical Modeling. 2nd ed. Amsterdam: Elsevier Academic, 2004. Print.
3. E.Carson and C. Cobelli (Eds.), Modelling Methodology for Physiology and Medicine, Academic Press, San Diego, CA, 2001.