Mapping Topics for Program Enhancement in Undergraduate Process Engineering Education

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Abstract

Identifying recurring themes and creating a topics map provides a useful tool for program enhancement. Topic maps can be used to streamline teaching and create opportunities for introducing supplementary topics. It encourages consistency and continuity within a program and opens dialogue among faculty members. It gives students context for their current learning within the overall program picture. This paper examines how the Discipline of Process Engineering at Memorial University collectively examined their program, identified seven common themes and mapped their evolution through the program. The outcomes of this examination will be presented and potential implementation strategies to further enhance the program and assist student learning will be discussed.

1 Introduction

In establishing learning outcomes as part of Memorial University’s approach to assessing graduate attributes, Process Engineering faculty went on to examine the topics or concepts that constitute the program. Creating a concepts map was motivated by a interest in improving student learning and program efficiency, ensuring the validity of course outcomes and demonstrating a commitment to continuous improvement as required by the Canadian Engineering Accreditation Board (CEAB).

Topics and concepts were featured in typical course outlines and represented a starting point for developing learning outcomes. To ensure that the outcomes were at the appropriate level, and to minimize redundancy and omissions, the concepts that formed the basis for the outcomes needed to be examined for complexity, redundancy and omission as well [1].

Mapping topics or concepts can help educators plan an efficient course, series of courses or an entire program. Concept maps enable educators to identify redundancy, omission, complexity, misconceptions and which items to assess [2]. In addition to a traditional curriculum map, a concept map was created for Process Engineering at Memorial University as a collective effort to represent concepts that flow through the program. The concept map was created to visually represent the relationship between topics or concepts and create an opportunity for faculty members to provide, and receive, input on individual courses.

2 Results and Discussion on Mapping Concepts in Process Engineering

Process Engineering faculty members and staff developed the concept map collectively. First, categories of topics that represented central themes in Process Engineering were established. These categories were fundamental science, engineering science, design, engineering tools, sustainability, industry knowledge and modeling. This was a group exercise with faculty collectively developing the concept categories.

Categories of topics present in courses were individually identified, along with the level of complexity associated with each concept or topic. Faculty members shared the concepts in their courses with the group by posting them on a Topics Wall. The Topics Wall listed the topic categories down the left side and the levels, Introductory, Intermediate and Expert across the top. Using colour coded adhesive notepaper; faculty added their course topics to the appropriate category and level.

Figure 1: Topics Wall
The map was examined and discussed to ensure that concepts flowed from introductory to expert in a logical manner, areas of overlap were identified and possible omissions were highlighted. Examining the curriculum in this type of group setting allowed for effective collaboration. Faculty members were able to examine the concepts of the entire program together, discuss sequencing, as well as teaching, learning and assessment techniques. Concept maps are a vehicle to facilitate collaboration and the sharing of perspectives [2].

The concept map facilitated several productive discussions about the development of concepts in Process Engineering. For example, it prompted the group to consider the appropriateness of introductory level concepts in senior courses. A discussion ensued resulting in some concepts being reclassified with respect to level, some concepts being relocated to courses earlier in the program and others being deemed appropriate and remaining unchanged. Collectively examining the topics map resulting in some concepts being reordered to provide better sequencing. Some concepts were redundant and removed from courses, allowing for the addition of other topics. In other cases, where it was identified that students had previous exposure to the topic, subsequent courses were able to treat the concept with more depth and introduce more complexity.

2.1 Concept Map Applications

2.1.1 Identifying and sequencing fundamental themes

Thermodynamics is a concept that is fundamental to study of Process Engineering. As the concept map was created, thermodynamics emerged as a recurring theme that crossed topic categories and levels. The study of thermodynamics in the Process Engineering Discipline at Memorial University begins with first year Chemistry and culminates in the senior capstone project in Process Engineering Project II. Students begin with studying introductory concepts such as the first law of thermodynamics, which states that the internal energy of an isolated system is constant; energy cannot be created or destroyed, and progress to having the ability to apply advanced state modeling equations in the design of processes.

Throughout the program, thermodynamics recurs in a variety of courses. It is used to define the limits or boundaries for transport phenomena and chemical and biological reactions. It is used to determine the feasibility of all process designs. In short, one cannot successfully study process engineering without a firm foundational understanding of thermodynamics.

Creating the concept map highlighted thermodynamics as a fundamental concept in the program. The map enabled faculty to ensure that the sequencing of this concept was carefully considered and it allowed for cooperation across courses to ensure continuity of study for the students.

2.1.2 Planning assessments

Concept maps identify fundamental themes and highlight areas of importance for assessment. Because they provide a visual representation of which concepts are most important and need to be assessed, concept maps can provide assistance when preparing exams, projects, labs and assignments [2].

2.1.3 Sharing concept maps to enhance student learning

Sharing a concept map with students allows them to construct a big picture view and enables them to understand how individual topics fit into the program. Students can understand individual topics without being able to see how they all fit together [2]. Rather than seeing thermodynamics as a series of separate topics in individual courses, it is beneficial for students to understand how the study of thermodynamics ties together. Evidence shows that this type of global understanding enhances learning and increases student achievement [2]. The Process Engineering Topics Map will be shared with students electronically and in a large format wall-hanging for easy reference during lectures.

Figures 2 and 3 show a map of the graduate attributes with competency levels for courses in the Process Engineering program of study. Maps of this type were eventually incorporated into the documentation for application to CEAB accreditation.
2.1.4 Implementing curriculum changes

Feedback from the accreditation process suggested some modifications in sequencing. Engineering 5621 Process Modelling and Analysis (ENGI 5621) was studied concurrently with Engineering 5601 Mass Transfer (ENGI 5601), and before Engineering 6631 Chemical Reaction Engineering (ENGI 6631). ENGI 6631 and ENGI 5601 are now concurrent and studied before ENGI 5621. The concept map was used to ensure that changes to the sequencing of courses did not negatively impact the sequencing of concepts. The concept map enabled faculty members to efficiently make changes and evaluate the potential impacts of reorganization.

3 Discussion

With a concept map in place, responses to feedback from accrediting bodies, or students and industry focus groups can be made efficiently. Concepts and their development throughout the program have been clearly identified so changes that impact multiple courses are readily identified. This allows for the maintenance of proper sequencing as the program evolves to meet the educational requirements of its students [2].

With many learning outcomes to meet and graduate attributes to attain, faculty may seek a balance in covering topics and treating them with the appropriate depth. To ensure a broad understanding of the discipline, along with critical concepts, they also seek to include as many additional topics as possible without overwhelming the students. Mapping topics and concepts allowed faculty to identify redundancies, creating opportunities to treat concepts at a higher cognitive level and introduce new, complimentary areas of study [3].

Concept maps have significant impacts on student learning. In addition to the benefits of proper sequencing of concepts, identifying context for an individual concept and its role in the overall program has a positive impact on student learning. Students can struggle with integrating concepts when they don’t see the bigger picture [2]. Sharing the map with students allows them to see how concepts come together to form a more complete understanding of Process Engineering. A visual representation allows students to locate learning outcomes within the context of the program. If learning outcomes are the reference points that help students navigate the college curricula, a map must be provided so that they can locate those reference points in the broader topography [4]. A program of study is greater than the sum of its parts. Seeing the complete picture is more meaningful for teachers and students than a random collection of pieces [1].

4 Conclusion

The collegiality and collaboration fostered by generating a concept map not only allows for a better articulation of the curriculum, it allows the participants to openly share their knowledge of, and experiences with, teaching and learning [3]. This collegiality and collaboration has contributed to the establishment of a teaching and learning community within the Process Engineering discipline. Keeping the curriculum and the concepts it contains relevant through collaboration increases faculty members’ interest and engagement in teaching and learning. It
allows the curriculum to evolve along with disciplinary knowledge and student needs [5]. One of the most important features of constructing concept maps is that it forces educators to re-consider and question assumptions held about their subject area [2]. Collectively creating and examining a concept map has encouraged a fresh look at the curriculum, and teaching and learning practices, in Process Engineering at Memorial University.

References


