A Pedagogy for Microcredentials in Engineering Education: The MacAccess Example

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I. Introduction

The contemporary concept of microcredentials offer a more flexible and compact framework for learning and verifying skills/knowledge attainment. A more complete definition currently used by McMaster University is provided in [1]. The common characteristics of micro-credentials are,

1. Skills and competencies-based
2. Short in duration
3. Assessable
4. Modular and stackable
5. Personalized
6. Verifiable

The challenge for most North American post-secondary institutions to introduced micro-credential based programs often arise from conflict with academic tradition. In Ontario, most institutions offer 4-month semester courses that are taken serially by entire cohorts of students. Consequently, the essential qualities 2, 3, and 4 from the foregoing list are inconsistent with prevailing course structure.

Qualities 1 and 5 are common to both planned micro-credentials and current academic practice. Indeed, most North American institutions, especially in applied programs such as engineering, have a professed commitment to hands-on, project-based, work-integrated, and other forms of experiential learning (e.g. at McMaster [2]). Arguably, item 6 is a strength of the traditional academic programs and represents a challenge for micro-credentialized programs to address.

The MacAccess initiative proposes to develop a framework to allow conventionally defined engineering courses to be efficiently reformulated and delivered as modern micro-credentialled variants. The intent is to have the new courses embody the desired flexibility and related qualities while maintaining the rigour and outcomes inherent in the conventional courses. This allows possible future options for full-time and non-full-time students. The project is exploratory in nature and will execute pilots drawn from suitable initial topics. The target start date for the first courses is the Winter semester of 2024.

MacAccess was conceived at the Walter Booth School of Engineering Practice and Technology within the Faculty of Engineering at McMaster University, Canada. The Booth School is known for its applied and practice-based learning approach to curricular programming.

II. Program and Course Structure

A key novel contribution of the MacAccess design of courses is a basic "rhythm" of 3. A micro-credentialled equivalent of a conventional McMaster "3-unit" course (nominally a 4 month semester course of 13 active instruction weeks and 3 instruction hours per week) is defined as a flexible sequence of 3, one month-long "modules", labled M1, M2, M3. A typical 3-module course will also exist with a sequence of courses. For example, if a topic warrants 3 courses (e.g. C1, C2, C3), there will be a total of 3 *modules* x 3 *courses*, or 9 modules. The difference, however, from conventional courses is that each module, to the extent that is reasonable and appropriate, is self contained and can be taken in non-serial sequences. Moreover M1, M2, and M3 respectively embody a particular pedagogical approach that align with specific learning outcomes (Fig. 1).

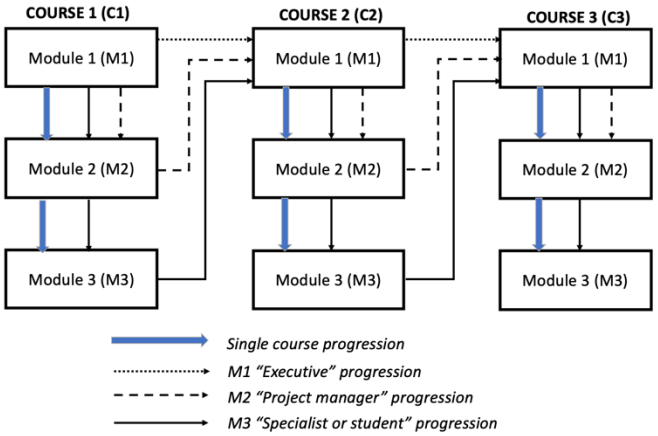

Fig. 1. *MacAccess learning module and course progressions*

The intended learning outcomes for the three modules are, respectively,

M1 "Executive" progression: The outcome is a system-level literacy of the most essential concepts. Following an M1 module, a learner is expected to be able to more confidently and productively participate in a design or project team on the topic, even if they do not have a specialized background in the topic. Typically, M1 modules will focus on the vocabulary and inherent taxonomies of a complex topic.

M2 "Project manager" progression: the outcome is the ability to manage, guide, or, more broadly, work with the component, connectivity, and broad inter-dependence or dynamical aspects of a complex system or application. Typically, M2 modules will focus on the tools commonly encountered within a complex topic context.

M3 "Specialist or student" progression: the outcome is a basic skills/knowledge capacity to competently synthesize an appropriate solution to complex or open-ended challenges

within a complex topic context. Accordingly, M3 modules will focus on the application aspects.

An initial treatment of a course topic will require eventual completion of the three modules, and for very practical reasons, the most efficient sequence will likely be the M1, M2, M3 sequence – i.e. equivalent to a traditional 3-unit course. However, the core flexibility is derived from the fact that a learner does not need to go past a particular module level. For example, if a learner is a practitioner needing to upgrade their understanding of machine learning, they can focus on the M1 levels of three courses. Ultimately, such a sequence will provide the learner with the essential literacy and high-level insights to function in strategic planning, product management, external communications, etc. Hence the label "Executive" sequence alluding the type of professional who may benefit most from the M1 level.

III. Pilot topics

MacAccess pilot topics are drawn from three contemporary high-demand domains that also align with particular program priorities at the Booth School and the Faculty of Engineering:

Artificial Intelligence: The Booth School's current complement of undergraduate and graduate courses already offer a distinctive application-centric perspective on this timely topic. Three particular courses will be selected and reformulated to the MacAccess model.

Innovation and Entrepreneurship: The Booth School's successful GENTECH undergraduate program and the School's recently discontinued Master of Engineering Entrepreneurship and Innovation (MEEI) graduate program will form a foundation of three select courses aimed at introducing a unique blend of innovation-aligned topics within a robust engineering and technology context.

Sustainability and Circular Economies: A current topic of discussion is to leverage various sustainability-themed courses to address a distinct lack of practical modern courses in this very important theme.

As an initial step, the new MacAccess-aligned course variants will first exist as a refined version of the conventional 3-unit course that current McMaster students would take as part of their regular course load. These revised courses, however, will have a structure and tuned content that will readily adapt to actual micro-credentialled program form once the anticipated delivery platform and processes are in place.

IV. Pedagogical foundation

As much as MacAccess is motivated by the increased flexibility and reach of micro-credentialled, high-quality courses, the resulting definitions and framework has been derived from formal pedagogy, including the cognitive foundations of experiential learning [3] and the basic cadence or "rhythm" of the learning progression [4].

At a more practical level, some basic industry trends had a major influence on the initial choices of pilot topics. In particular, the American Society of Engineering Education notes that advanced contemporary technologies such as AI and data science, and generalized technical systems are considered not well addressed by conventional engineering programs [5].

V. Implementation challenges

Among the many challenges that any curricular transformation would trigger, MacAccess has already identified several particularly vexing obstacles that continue to draw significant research energies.

Delivery platform: Although the learning management system (LMS – e.g. D2L's Brightspace or "Avenue" at McMaster) offers the features to deliver the course content, new software mechanisms will be developed to coordinate and manage the required flexibility and modularity, and deal with learner registration, payment, and support.

Course development and migration: efficient conversion of a traditional course to MacAccess format that preserves the original academic intent but embodies the enhanced learning and flexibility benefits is required, and migration tools and processes are currently being developed to address this challenge.

Curricular reconciliation: Although McMaster does have clear definitions of microcredentials and related concepts such as certificates and badging, they are not well-aligned with the core degree. Indeed the intent of the initiative is to find effective mechanisms and refined definitions to bridge this gap. This will depend on greater efforts in mapping respective learning activities with verifiable outcomes.

VI. Conclusions

MacAccess represents a conscientious effort to modernize engineering programs to respond to changing societal and institutional priorities. A unique dimension in the program design is the novel blend of formalized pedagogy with a very pragmatic and process-focused development and delivery framework.

VII. Acknowledgements

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