Curriculum content measurement: Beyond the AU

Canadian Engineering Accreditation Board

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Abstract

While the Accreditation Unit (AU) has been an integral part of the Canadian Engineering Accreditation Board (CEAB) criteria for almost 25 years, it may be time to consider alternative methods of curriculum measure as curriculum delivery methods are evolving. As the engineer- ing profession is regulated through an exclusive right-to-practise licence in order to safeguard public safety, the regulators establish rigorous academic standards for admission to the profession. While other professions rely on standardized technical exams to ensure that each individual meets the admission requirements, the engineering regulators in Canada have the confidence that the minimum path requirements within the CEAB criteria achieve the same end. As a result, CEAB graduates are not assigned additional technical exams when applying for their licence.

While the CEAB criteria includes criteria related to a program in general, this paper is concerned with the minimum path curriculum content criteria. The criteria serve two purposes: they define both the minimum program length and the mix of the broad curriculum elements of natural sciences, mathematics, engineering science, engineering design, and complimentary studies. The method of measuring curriculum for both these purposes has evolved from the use of the academic year before 1995 to the current contact time-based AU.

This paper proposes that the curriculum measurement for the two purposes be decoupled. To determine the program length, a model four-year program schedule is proposed that could be used a reference when considering alternative measures. Under the existing AU analysis, this reference program is 1,850 AUs in length. Similar analysis can be done with a proposed learning unit (LU). The mix of curriculum elements alternatively can be specified as percent- ages of the minimum total. The institution would be free to choose a consistent method of determining the percentage of each element as appropriate which may include their own academic credit or even the existing AU. If these proposals still provide the regulators sufficient confidence in the rigour of the accreditation process while also allowing educators further freedom to innovate in their delivery of curriculum, then their adoption within the criteria should be considered.

1. Introduction

It has been almost 25 years since the Canadian Engineering Accreditation Board (CEAB) introduced the Accreditation Unit (AU) as the primary method of measuring curriculum within its criteria. As the engineering curriculum evolves to meet the challenges with the emergence of what some are calling the fourth industrial revolution, it may be time to revisit the use of the AU as a curriculum measurement within the CEAB criteria.

The curriculum measurement criteria is a key component of the CEAB accreditation process. Since the criteria applies to each and every graduating student, it is considered a “minimum path” requirement. While many other right-to-practise regulators require both an accredited education and the passing of standardized technical exams for admission, the engineering regulators in Canada exempt graduates of CEAB accredited programs from writing further technical exams. It is the minimum path requirement and the rigour of the academic assessment by the CEAB which give the regulators confidence that they are fulfilling their mandate of protecting the public when issuing a licence to a CEAB graduate.

One of the important principles of the CEAB criteria is that they should provide sufficient room for educational institutions to innovate in curriculum development and delivery. As such, the curriculum content requirements define a very broad mix of curriculum components. Further, they are silent on the delivery methods used. This flexibility has allowed Canadian universities to develop a diverse set of engineering program offerings using a range of pedagogical approaches.

The challenge, however, is to specify a set of criteria that, on one hand, has the necessary flexibility for innovation, but on the other hand, satisfies the regulators of the rigour of a program. Over the years, the approach to curriculum measurement has evolved. In the past, it was based on the academic year, but now the AU is used which is based on structured contact time. While the AU was created in response to the concerns of the educational institutions of the time, as the engineering educational environment continues to evolve, concerns are again being raised by engineering educators.

This discussion presents an opportunity to think beyond the AU as the sole measure of curriculum content. Can an alternative curriculum measurement framework be developed that provides institutions more flexibility to adapt to evolving educational methods while maintaining the same level confidence the engineering regulators have with the current system?

This paper further examines the above issues relating to the use of curriculum measurement within the CEAB criteria and suggests a potential path forward. The following section describes the regulatory framework for professional engineering in Canada as the context for which the accreditation process serves. An overview of the current criteria components follows next. A brief history of the evolution of the curriculum measurement criterial in the next section provides the historical context. Some of the current issues with the existing curriculum measures are then discussed including an overview of the work of the AU Task Force. Two approaches to moving forward with changes to specifying curriculum content are then proposed, followed by the final summary, conclusions, and recommendations for moving forward.

2. Context: Professional engineering in Canada

2.1 Right- to-practice licence

The regulation of the practice of professional engineering across the country is somewhat unique internationally as Canada is one of the few jurisdictions in the world with an exclusive right-to-practice licence for engineering, on par with such other professions as medicine and law. Other engineering organizations may have an exclusive right to title — one cannot call themselves a Chartered Engineer in the U.K. without joining the appropriate engineering institution by having fulfilled the necessary membership requirements — but there are no general restrictions on who can do engineering work.

This exclusive right-to-practise licence means that the regulators are, in effect, in the business of restriction of trade. They enforce not just on title, but on practice; they issue a licence to practice to only those qualified; and they may revoke that licence as a disciplinary penalty.

Society, through provincial and territorial statutes, grants the regulators such restriction of trade powers, understanding the safety risks of having unqualified people doing engineering work.

Buildings and bridges shouldn't collapse, vehicles shouldn't pose a danger to drivers or those around them, electrical power infrastructure should be safe and secure, and chemical plants should not fail, causing environmental damage. Society has been willing to restrict trade in these areas because the danger to the public of having unqualified work is clear.

2.2 Admissions and exams

One of the key components of this contract between regulator and society is a rigorous admissions process that ensures that each and every licence holder has met a minimum level of competency as appropriate to the profession as established by the regulator. For most other right-to-practise regulators, the typical standard for admission that ensures such an individual-based minimum competency requires, in addition to graduating from an accredited degree program, the passing of a set of standardized technical exams. For example, the law societies have their bar exams and the colleges of physicians have their board exams. In these cases, the professions may have a well-defined body of knowledge that lends itself to standardized exams. However, due to the diversity within engineering, such standardized exams may not be feasible.

2.3 Canadian Engineering Accreditation Board

For the engineering profession in Canada, Engineers Canada, the national organization of the 12 Canadian provincial and territorial engineering regulators, established the Canadian Engineering Accreditation Board (CEAB) in 1965 to accredit Canadian undergraduate engineering programs on behalf of the regulators. Applicants for licensure to any of the Canadian engineering regulators who are graduates of engineering programs accredited by the CEAB are deemed to have met, or exceeded, the educational standards required for licensure. No further technical exams are required by the regulators. This departure from more traditional licensing systems requiring technical exams is due to the unique, dual nature of the criteria under which the CEAB grants accreditation status.

The CEAB criteria includes aspects found in most other modern accreditation systems: curriculum analysis, student environment, academic and support staff, and facilities, and resources. Recent additions to these criteria now require institutions to define and evaluate a program's graduate attributes and establish a continual improvement process for curriculum renewal. Many of these criteria apply to the program in general. For example, the degree to which students meet the individual attributes need only be determined by a statistical sampling of student performance.

2.4 Minimum path: Licensing the individual

While these program-based criteria are common to other accreditation systems, the CEAB criteria also include rigorous, student-based criteria. These criteria follow the "minimum path" principle: every student in a program must meet the criterion for the criterion to be met at the program level. As part of the curriculum analysis, the over-all length of the program is defined. In addition, minima are defined for specific curriculum components: mathematics, natural sciences, engineering sciences, engineering design, and complementary studies. The institution must show that every graduate of the program meets the minimum standards. During an accreditation visit, the institution must also provide for every course in the program the course notes, textbooks, examinations, tests, labs, projects, etc., including graded student examples for key courses.

It is the review of this course material, coupled with the detailed curriculum analysis that gives the regulators confidence in the technical rigour of a program. If the CEAB, through the visiting team, is satisfied with the rigour of, say, the thermodynamics exam, or other such assessments, then there is no need for the regulator to assign an additional thermodynamics exam as part of the licensing process. Further, even the technical exams for applicants not from CEAB-accredited programs are set by engineering faculty who teach such courses in CEAB-accredited programs. The minimum path requirement ensures that every applicant applying for license has the minimum technical competencies the regulator requires. In effect, the CEAB system combines the accredited education and technical board exams into one unified process.

However, such thorough, student-based, minimum path curriculum analysis is not part of most other accreditation systems. Therefore, it makes sense that other regulators would need additional board exams to ensure that each and every applicant meets the requisite minimum level of technical expertise.

3. Current CEAB criteria

3.1 Criteria overview

According to the *Purpose of Accreditation*[1], "The process of accreditation emphasizes the quality of the students, the academic and support staff, the curriculum and the educational facilities." As such the criteria encompasses a broad range of components as part of the educational experience of a program.

The newest additions to the criteria, which came into effect in 2015, *3.1 Graduate attributes* and *3.2 Continual improvement*, are explicit, outcome-based criteria. The incorporation of such outcomes-based criteria into the accreditation process was a requirement of Engineers Canada's signatory status in the Washington Accord, an international agreement recognizing the educational degree qualifications for an engineering designation among the signatory organization. While the twelve attributes are defined in the CEAB criteria, institutions define their own indicators, tools, and processes for continuous improvement as appropriate for their institutions and programs. As the attributes are program-based, they are not individual-based, minimum-path criteria.

Section *3.3 Students* is concerned with admissions, promotion and graduation, academic advising, and degree auditing. As these criteria deal with the policies and procedures for individual students, they are, in effect, minimum-path criteria since the institution must demonstrate that "all its student-related policies, procedures, and regulations apply to, and are met by, all students."

The section on curriculum content measurement, *3.4 Curriculum content and quality*, "are designed to assure a foundation in mathematics and natural sciences, a broad preparation in engineering sciences and engineering design, and an exposure to non-technical subjects that supplement the technical aspects of the curriculum." Since the criteria explicitly states, "All students must meet all curriculum content and quality criteria," it is a set of individual-based, minimum-path criteria. The issue of curriculum content measurement is discussed in detail further below.

The last two sections, *3.5 Program environment* and *3.6 Additional Criteria*, are concerned with the

[1] Unless otherwise noted, all references to the criteria are to the *2018 Accreditation Criteria and Procedures of the Canadian Engineering Accreditation Board*

quality of the educational environment. They encompass such aspects as support staff, faculty expertise, leadership, curriculum processes, options, and program name. Since these criteria apply to the program and not individual students, they are not minimum-path criteria.

3.2 Curriculum Content and Quality

As mentioned above, the more typical route for admission to other right-to-practise professions requires all applicants to pass standardized board exams. This admission requirement ensures that every successful applicant meets a minimum level of technical knowledge and/or competencies required by the profession.

For example, the eligibility for the Professional Engineering (PE) from American state engineering boards includes an engineering degree accredited by the Accreditation Board of Engineering and Technology (ABET), four years of engineering work experience, and the passing of both the Fundamentals of Engineering (FE) standardized examination and Principles and the Practice of Engineering (PE) standardized examination, both administered through the National Council of Examiners for Engineering and Surveying (NCEES). Both ABET and NCEES are independent, non-governmental organizations. They work with various engineering technical societies (such as the American Society of Mechanical Engineers (ASME), the Institute of Electrical and Electronics Engineers (IEEE), etc.), who typically define discipline-specific model curricula that are used as the basis for discipline-specific required curriculum content in the case of ABET, and technical exams in the case of NCEES. For example, the NCEES offers six separate standardized discipline-specific FE exams in addition to one “other disciplines” FE exam.

The CEAB takes a broader approach to specifying curricular elements for an engineering program. The CEAB criteria do not include program-specific subject matter requirements for a given engineering program. As long as “the academic level of the curriculum [is] appropriate to a university-level engineering program,” the institution is free to develop innovative curricula within a very broad set of curriculum-content requirements. One of the principles of the accreditation criteria is the recognition that institutions must be free to innovate as engineering fields evolve. In the *Purposes of Accreditation,* this principle is stated explicitly:

> “The criteria for accreditation are intended to provide a broad basis for identifying acceptable undergraduate engineering programs, to prevent over-specialization in curricula, to provide sufficient freedom to accommodate innovation in education, to allow adaptation to different regional factors, and to permit the expression of the institution’s

individual qualities, ideals, and educational objectives. They are intended to support the continuous improvement of the quality of engineering education."

Further, even the name of an engineering program is open for the institution to choose, as long as it is "properly descriptive of the curriculum content."

The effect of this flexibility has been the creation of a wide range of innovative engineering programs across the country. Over 100 differently named programs have been accredited by the CEAB over the years from Aeronautical Engineering to Water Resources Engineering. It allows institutions to offer very non-traditional engineering programs such as Systems Design Engineering, as well as create new programs in emerging fields like Nanotechnology Engineering. Educational institutions have thus been able to rightly take a leadership role in defining engineering practices beyond the scope of the traditional engineering disciplines.

3.3 Curriculum content measurement

The curriculum content measurement criteria specified within section *3.4 Curriculum content and quality* fulfil two objectives:

- they specify the overall length of an acceptable engineering degree through a minimum total measure, and
- they specify the mix of the broad curriculum components of mathematics, natural sciences, engineering science, engineering design, and complementary studies.

The former objective defines the minimum length of an engineering degree program as the expected norm of four years. The length of time is a significant differentiator between an acceptable four-year engineering degree and, for example, a three-year diploma.

The latter objective specifies the mix of curriculum components that defines the essence of an engineering degree without imposing a detailed, discipline-specific curriculum. A key component of an engineering degree is a broad foundation in mathematics and natural sciences. These minima prevent over-specialization in the specific technical subject matter of the curriculum. They also ensure that the program provides sufficient exposure to non-technical areas, to develop "an understanding of the environmental, cultural, economic, and social impacts of engineering on society." As well, the emphasis on engineering sciences and engineering design differentiates an engineering degree from say an applied science degree.

It is the use of deliberately broad curriculum components in the criteria that have allowed the innovation in engineering curriculum seen in the higher educational institutions across the country. Further, save for the requirement that "appropriate laboratory experience must be an integral component of the engineering curriculum," the criteria are silent on the instructional methods used to deliver the curriculum components of a program.

While the overall principle of curriculum content measurement as a core component of the accreditation criteria and the two objectives it serves has not changed over the years, the methods of measurement have evolved and are still an active topic of discussion.

4. Curriculum measurement evolution

4.1 Pre-1995: The academic year

Prior to 1995, the measurement of curriculum components was based on an effective academic year. The 1994 criteria defined an academic year as "26 weeks of instruction, over and above periods allotted to examination."

4.1.1 Program length

The over-all length of a program was equivalent to a "reference program of four years' duration."

4.1.2 Curriculum mix

The minima for each curriculum component were specified as:

- Mathematics: One half year (12.5% of a four-year degree)
- Basic sciences: One half year (12.5%)
- Engineering science: One half year (12.5%)
- Engineering design: One half year (12.5%)
- Engineering science and engineering design: Two years (50%)
- Complementary studies: One half year (12.5%)

Given a minimum four-year degree, the criteria left the content of at least one half year (12.5%)

unspecified as other curriculum content.

However, the criteria explicitly allowed exceptions to these criteria: "The CEAB gives sympathetic consideration to departures from these criteria in any case in which it is convinced that well-considered innovation in engineering education is in progress."

4.2 Problems with the academic year

Despite the apparent simplicity of this approach to curriculum measurement, the educational institutions raised concerns with the academic year measurement approach. Dwight Aplevich, CEAB Chair 1993–1994, recalls[2],

> "This measure caused endless discussion because the year is generally not used in this way in universities and because Canadian programs vary greatly in both nominal and effective length. It forced the CEAB and universities to calculate in relative measures of program length in order to estimate whether the criteria were met; for example, a half-year of basic sciences was interpreted as one eighth of the program. In 1990, the National Committee of Deans of Engineering and Applied Science (NCDEAS) officially requested changes in its annual report, specifically that '*In all cases the requirements are to be met in terms of the absolute amount of instruction, not the proportion of a particular curriculum*'. André Biron, CEAB chair in 1990–91, supervised a project to implement the NCDEAS request. From discussions at the time, it is clear that had all Canadian universities a credit system such as in Québec, the CEAB probably would have used it; but only the majority of institutions define a credit and not all definitions are the same, so a separate but compatible unit had to be defined. The CEAB accreditation unit (AU) is directly related to the credit hour in universal use in the U.S. and is compatible, by definition, to the credit in any Canadian university by the use of the appropriate scale factor. In fact, the CEAB criteria explicitly state that the AU need not be used when it is seen to be inappropriate. . . . The AU was duly approved by the NCDEAS and has been used to measure program size or volume since 1995."

4.3 1995: The accreditation unit

The accreditation unit (AU) is defined as:

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[2] Dwight Aplevich, *An Armchair View of Engineering Accreditation in Canada*, May, 2017

- one hour of lecture corresponding to 50 minutes of activity, or
- two hours of laboratory or scheduled tutorial

As noted, this measure, based on structured contact hours, is analogous to the credit hour or Carnegie unit widely used in the United States and elsewhere.

4.3.1 Program length

Aplevich further notes, "One constraint on the introduction of the AU was that it should not change any existing accreditation decisions. The electrical engineering or equivalent programs in all Canadian institutions were analysed to establish what the numerical criteria should be. All programs except one, a 105-credit degree, were seen to have at least 1,800 AU."

While the minimum total number of AUs for a program was nominally 1,800, effectively it was larger. The 1997 criteria states, "The entire program must include a minimum of 1,800 AU. It is expected that accredited programs will continue to have additional AUs to demonstrate innovation and to achieve the special goals that a particular engineering school may have for an education in engineering."

4.3.2 Curriculum mix

Except for a slight reduction in the mathematics component, the minima for each curriculum component were simply converted to AUs proportionally from the previous academic year specification as:

- Mathematics: 195 AUs (10.8% of 1,800)
- Basic sciences: 225 AUs (12.5%)
- Engineering science: 225 AUs (12.5%)
- Engineering design: 225 AUs (12.5%)
- Engineering science and engineering design: 900 AUs (50%)
- Complementary studies: 225 AUs (12.5%)

Given a minimum total AU count of 1,800, at least 255 AUs (14.2%) remained unspecified as other curriculum content.

4.3.3 K-Factor

With the introduction of the AU as a contact hour-based curriculum measurement, the CEAB recognized that there would be cases where the AU would not be an appropriate measure of curriculum content. The 1995 criteria where the AU was first introduced states that:

> "For an activity for which contact hours cannot be used to properly describe the extent of the work involved, such as significant design or research projects or similar work officially recognized by the institution as a degree requirement, an equivalent measure in Accreditation Units must be used by the institution to be consistent with the above definition. One method for determining this equivalence, when a unit of academic credit is defined by the institution to measure curriculum content, is a calculation on a *proportionality basis*."

Thus, the "k-factor" was created.

The k-factor was designed to convert such courses that are measured by an institution's own curriculum measurement system, e.g., academic credits, to an equivalent number of AUs. The conversion factor, *K*, in units of AU per academic credit for example, is calculated using other traditional courses in the program as:

$$K = \frac{\sum \text{AU for all common and compulsory courses for which the computation was carried out on an hourly basis}}{\sum \text{units defined by the institution for the same courses}}$$

Note that the criteria explicitly states that the k-factor is not the only alternative to the AU for measuring curriculum content; it is simply one possible method.

4.4 Today: Current status

4.4.1 Post-1995

One of the issues institutions raised with the new total AUs criteria was the explicit expectation within the criteria that programs have additional AUs beyond the stated 1,800 number. While some considered a 10% addition to be sufficient, the lack of specificity left this criterion open to debate. In response to the institutions' concerns, the CEAB established an exact minimum of 1,950 AUs that accounted for the expected additional AUs, an 8% addition to the previous 1,800 number that did not impact previously accredited programs. Since this change in 2014, the CEAB no longer requires a program to have more than the revised minimum of 1,950 to satisfy the program total criterion.

The emergence of software engineering and other such programs with a focus on information technologies initiated another revision to the criteria. Compared to more traditional engineering programs, it was recognized that these programs have a higher reliance on mathematical foundations and less so on the natural sciences. As a result, the CEAB revised the criteria to reduce the minimum AUs in natural sciences by 30 AUs while keeping the total natural sciences and mathematics AU minimum at the previous 420 AUs to provide additional flexibility.

4.4.2 Program length

Currently, criterion 3.4.6 requires that "The program must have a minimum of 1,950 Accreditation units that are at a university level."

4.4.3 Curriculum mix

The current minimum curricular component requirements, as specified in criteria 3.4.2–3.4.5, are:

- Mathematics: 195 AUs (10% of 1,950)
- Natural sciences: 195 AUs (10%)
- Mathematics and natural sciences: 420 AUs (21.5%)
- Engineering science: 225 AUs (11.5%)
- Engineering design: 225 AUs (11.5%)
- Engineering science and engineering design: 900 AUs (46.2%)
- Complementary studies: 225 AUs (11.5%)

Given a minimum total AU count of 1,950, at least 405 AUs (20.8%) remained unspecified as other curriculum content.

5. Current issues

5.1 Curriculum measure

The suitability of using contact hours as a measure of curriculum content has been raised by the educational institutions. This discussion is not limited to engineering programs in Canada, nor is it a recent conversation. Shedd notes that while the credit hour was established over a century ago, "the measure itself has remained essentially unchanged. Whether that is attributable to its adaptability or a sign of the basic calcification of higher education remains an open question." [3]

There is a growing body of research within the scholarship of teaching and learning demonstrating that more active learning activities achieve better learning outcomes than the more passive traditional lecture approach. As a result, institutions are incorporating more active learning components into their curricula. Such approaches include problem-based learning, project-oriented courses, "flipped classrooms," experiential learning for credit, to name but a few. There is a desire to move the model of teaching in higher education "from sage on the stage to guide on the side."[4]

With the increased recognition of the importance of student-centred learning, there is a movement away from contact hour-based definitions of academic credit within higher educational institutions. The European Credit Transfer and Accumulation System (ECTS) establishes a common academic credit for academic mobility that is based on total student learning time. The Quebec university system incorporates both structured learning time (e.g., lecture time) and unstructured student learning time in the common definition of an academic credit. Other universities in Canada such as the University of Guelph, the Royal Military College of Canada, and the Université de Moncton use overall student learning time to define their academic credit. However, this is approach has not yet been universally adopted across the country and, hence, there is still a heterogeneous mix of credit definitions to contend with.

The CEAB criteria does offer an alternative method of measuring curriculum content where the contact time-based AU is an unsuitable measure, the k-factor. However, the method assumes that the academic credit being converted into equivalent AUs is a better indication of the quantity of curriculum content than simply the number of lecture hours. If the academic credit is based on student learning time, one

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[3] J. M. Shedd, "The History of the Student Credit Hour," *New Directions For Higher Education,* No. 122, (Summer 2003), pp. 5–12

[4] A. King, "From Sage on the Stage to Guide on the Side," *College Teaching,* Vol. 41, No. 1 (Winter 1993), pp. 30–35

could argue that may be true. If, on the other hand, the academic credit is purely contact hour-based, then one is no further ahead. Further, the k-factor requires a set of lecture style courses to calibrate the conversion of the institution's academic credit to AUs. As much as there is a movement to reduce lecture-based delivery, there is of yet little evidence of an impending wholesale abandonment of the lecture in the foreseeable future. In any case, the criteria do urge an institution to use an "equivalent measure" where the AU is inappropriate and that such equivalent measures does not necessarily need to be the k-factor.

5.2 Program length

An additional issue which the institutions have raised is the over-all length of engineering programs. One concern the HEIs have raised is the number of students who take longer than the nominal four years to graduate. It has also been argued that since the over-all minimum was raised from 1,800 AUs to 1,950 AUs in 2014 there has been a corresponding increase in the length of engineering programs as a result. However, it is important to note, the earlier minimum was a *nominal* 1,800 AUs with the expectation of additional AUs, say, of 10%. The CEAB has recently undertaken a detailed statistical analysis to investigate any time-variance of the AUs.

While it is true that some programs do have significantly more AUs than the required minimum, there may be other factors involved. Some institutions may still deliberately include additional AUs out of concern that during accreditation a visiting team may disagree with the institution's AU determination and reduce the total number of AUs, resulting in a value below the minimum. As well, institutions may deliberately create programs which exceed the minimum out of their own accord, either to differentiate themselves or through curriculum inflation. As the body of knowledge in engineering increases over time, curricula must evolve to stay current. However, when subject matter is added to a curriculum, it is sometimes difficult to correspondingly remove material.

5.3 AU Task Force and the learning unit

In response to the increasing discussion about the AU's shortcomings as a measurement method in relation to newer education delivery approaches, the Accreditation Unit (AU) Task Force was established in February 2017 by the Executive Committee of the Accreditation Board. Its mandate is to:

- consider the definition of an AU in its present form (criteria 3.4.1.1) and to identify the advantages, disadvantages and ramifications of any definition change on existing criteria; and

- envisage how curriculum content requirements could be linked to student outcomes/graduate attributes whatever system of AU counts is used.

The task force membership included representation from the Accreditation Board, the NCDEAS, and regulators and regularly sought input from other stakeholder individuals.

In February 2018, the task force submitted their report which was received by both the Canadian Engineering Accreditation Board and the Engineers Canada Board. The task force report included four recommendations:

1. Define a Learning Unit (LU) as an additional method for measuring curriculum.
2. Equate one AU as equal to 2.5 hours of learning time (LU), inclusive of both structured and unstructured time.
3. Consult with accreditation stakeholders on recommendations 1 and 2.
4. Continue the initiative to explore the linking of AUs to GAs.

Recognizing that stakeholders of accreditation would be affected by any changes to the AU definition, the task force consulted with as many of those stakeholders as possible before making a final recommendation to the Board. The consultation focused on recommendations 1 and 2. The consultation was executed from March 21, 2018 to June 3, 2018 and culminated in the *AU Task Force Consultation Report*, which was considered by the Engineers Canada Board at their September 2018 meeting.

The accreditation stakeholder feedback received through the consultation process was reasonably consistent across respondents. After analysis, the task force identified four primary themes:

1. Stakeholders anticipate that the learning unit, as described, has the potential to offer sufficient flexibility to measure curriculum content that is not actual contact time between student and faculty members.
2. There is general support from stakeholders to execute a learning unit verification project.
3. Several stakeholders expressed caution around the auditability of the learning unit as defined in the task force recommendations.
4. Several stakeholders expressed caution around implementing any approved changes too quickly. Some recommended establishing an upper limit on the number of courses to which
5. the LU could be applied (some have suggested 10%).

The consultation found support for the Learning Unit recommendation from a number of stakeholders and no objection from others. It appears that the LU would address some of the concerns expressed about the limitation of current curriculum measurement methodologies. The AU Task Force then recommended to the CEAB that further investigation be undertaken in the form of a pilot exercise.

The AU Task Force has consulted with several individual HEI stakeholders, the NCDEAS, and the National Admissions Officials Group (NAOG) on their initial approach to the LU pilot project. The pilot as initially envisioned would identify select courses at a variety of HEIs and examine the applicability of the LU as a curriculum measure relative to the established AU and k-factor methods. These courses would include a range of delivery methods from the classical lecture-based delivery to more experiential and project-based methods.

In the course of consultation, HEI stakeholders raised concerns about the nature and scope of this initial approach. They have suggested an alternative approach which would examine the application of the LU to entire programs rather than a small sample of courses. The more limited scope as initially considered would not, in their opinion, elicit the necessary buy-in from the institutions due to the lack of perceived value in the exercise being too narrowly defined and a desire to avoid the added complexity associated with the use of more than one system for measuring curriculum content.

Additionally, the discussion on the minimum number of AUs that a program must have to meet criterion 3.4.6 (currently 1,950) had not been included in the task force's initial mandate, yet this issue has been raised regularly during all phases of the AU Task Force work.

Given the willingness of all parties to consider alternative methods for curriculum measure such as the LU, this may be an opportune time to take a further step back and re-examine the basic purposes of including curriculum measurement in the accreditation criteria, namely program length and mix of curriculum components. Is it time to decouple the two? Can the method of measuring program length be different from the measurement of curriculum mix?

6. Moving forward

6.1 Program length: A model program

It is clearly impossible to specify the structure of a “typical” engineering program. Even during the discussions in the 1990s leading up to the introduction of the AU, there was consensus that even a common definition of an academic year was problematic, let alone able to account for the range of curriculum delivery methods. One can imagine that the diversity of program delivery is even more pronounced today.

However, it may be still be useful to propose a model or reference program schedule as a basis for further discussion. If we take a classical, lecture-based delivery model, such a reference schedule could be constructed as follows:

- A four-year program consisting of 8 semesters each of 12.5 weeks of instruction
- Each semester has 5 courses with 3 hours of lectures per week
- Two modes of course delivery:
  - Standard lecture course with 3 hours of lectures and 1 hour of tutorials per week
  - Lab course with 3 hours of lectures and 2 hours of labs per week
- Mix of courses: 60% lecture (3 of 5 on average), 40% lab (2 of 5 on average)

Under the existing AU curriculum measurement method, each lecture course is 43.75 AUs and each lab course is 50 AUs. The total AU count for such a program is 1,850.

This model curriculum is 100 AUs short (the equivalent of 2 additional lab courses) of the current minimum of 1,950 AUs. Irrespective of the curriculum content, the question to pose is, does such a program have an acceptable length, and is it consistent with the pre-1995 requirement of a four-year degree? Note that the past establishment of minimum total AU counts was based on surveys of existing accredited programs at the time. If there was some analysis of the structure of a canonical program as a basis for such numbers, it does not appear to be available. If there is consensus that this model program would be satisfactory for accreditation purposes, then the minimum total AU count criterion should be revisited.

While such a model schedule is purely a construct, if it is accepted as having a satisfactory length for accreditation purposes, then any method of ascertaining the length of a program used in the accreditation criteria could be applied to the model to determine the appropriate minimum value. Any program with an alternative structure would then be deemed equivalent in the over-all length to this reference four-year program if a given measure is equal to that of this model.

For purely illustrative purposes, one could use the model to calculate a measure of expected student learning time as a reference. According the proposed LU, its equivalency to an AU is 1 AU = 2.5 LU. For the above model lecture course, this gives 109.4 LUs per course per semester, or equivalently 8.75 hours per week: 4 hours in class plus 4.75 hours of unstructured learning (reading, assignments, etc.). For the lab course, there would be 125 LUs per semester or 10 hours a week: 5 hours of structured time plus 5 hours unstructured (that also includes lab preparation and write-up, etc.). The model schedule would then require 46.25 hours of student work a week. Of course, there may be variations from course-to-course even for the same offering mode. However, as the length of the program is the total of all such hours across all courses, such variations could effectively average out. The question is, do these values seem reasonable given current practices? If so, then the total minimum LU count would be 4,625 hours. As long as a program with alternative delivery structures has the same number of student learning hours, it should be considered equivalent in length for accreditation purposes.

6.2 Curriculum mix: A percentage approach

In both the pre-1995 criteria and subsequent ones, the same measurement tool, the academic year and the AU respectively, is used to accomplish two different objectives: determine the program length and determine the curriculum mix. Is this appropriate? As the question was raised earlier, can, or should, the two measurements use different methods?

For determining the mix of curriculum elements, it was argued that the academic year, while conceptually quite simple, was too coarse a measure. Further, it did not adequately account for differences in curriculum delivery across the various institutions in the country. On the other hand, the AU has been faulted for introducing an inappropriate level of precision into the curriculum analysis process.

During the discussions leading up to the introduction of the AU, HEIs argued against a proportional method of measuring curriculum and advocated for an absolute measure, hence the AU. However, given an arbitrary measure of the total curriculum, each of the curriculum elements can easily be specified as a proportion of the minimum total and *vice versa*.

If we go back to the pre-1995 mix of curriculum elements and make some adjustments for subsequent revisions to the natural sciences and mathematics elements, we can establish the minimum criteria for each curriculum component as a percentage of the program as follows:

- Mathematics (M): 10%
- Natural sciences (NS): 10%
- Mathematics and natural sciences (M+NS) : 22.5%

- Engineering science (ES): 12.5%
- Engineering design (ED): 12.5%
- Engineering science and engineering design (ES + ED): 50%
- Complementary studies (CS): 12.5%
- Other unspecified (O): 15%

With a percentage approach, institutions could then have the flexibility to use the academic measurement of their choice to demonstrate compliance with the percentage-based, curriculum-mix criteria. Table 1 below illustrates some examples of how the approach would work in practice. For the first example, if a four-year degree program consisted of 120 academic credits in total, then the minimum for each curriculum component would simply be expressed in terms of the institution's academic credit using these percentages. An identical analysis could be undertaken if a program were defined in terms of courses, AUs, weeks, ECTS learning time-based credits, etc. As long as a consistent measurement system is used, the institution would be free to adopt a measurement system it feels is most appropriate to its program offerings.

		120 Credits	40 Courses	1,850 AUs	100 Weeks	240 ECTS Credits
M	10%	12	4	185	10	24
NS	10%	12	4	185	10	24
M + NS	22.5%	27	9	419	22.5	54
ES	12.5%	15	5	231	12.5	30
ED	12.5%	15	5	231	12.5	30
ES + ED	50%	60	20	925	50	120
CS	12.5%	15	5	231	12.5	30
O	15%	18	6	278	15	36

Table 1: Example calculations of percentage curriculum mix using different measurement methods.

It is important to note that these program total measures must be taken relative to the minimum program length as specified in the criteria. If a program length was greater than the minimum requirement, the reference length (the top row of the above table) would be reduced to reflect the lower minimum and the unspecified remainder would simply increase to reflect the longer program. For example, if a 150-credit program had 2,312 AUs, it would be 25% over the minimum length of 1,850. The reference number of credits for the above calculations would then be 150/1.25 = 120 credits, with the unspecified portion calculated as 15%×120 + (150-120) = 48 credits.

7. Summary and conclusions

Curriculum measures are an integral part of the CEAB accreditation criteria due to the minimum path requirement of these criteria. This, as part of the rigorous academic assessment of a program, gives the regulators confidence that they do not have to assign further technical exams to CEAB applicants in order to fulfil their regulatory obligations. While the method of measurement has evolved over time, the two purposes have remained consistent: specify both the minimum program length and the acceptable mix of curriculum components.

Currently the AU is used as the primary method of curriculum measurement. It is well-suited to the classical course delivery approach of lectures with tutorials or laboratories. However, as research within the scholarship of teaching and learning is finding, more active, student-centred learning methods can achieve improved learning outcomes. As a result, there is a movement away from contact-time definitions of academic credit to student-learning time. Unfortunately, while some institutions have adopted such definitions, there is still exists a very heterogeneous system of assigning academic credit across the country and hence a need for flexibility in any multi-institutional system of curriculum measurement.

By considering the two purposes of curriculum measure as separate problems, this paper proposes a measurement framework that has the potential for allowing such flexibility while maintaining the fundamental requirements in which the regulators have had confidence.

A model curriculum schedule is proposed that can serve as a reference for measurement methods that specify the minimum length of a program. If this model is considered a reasonable reference, then any given total curriculum measurement system applied to the model would specify a minimum value for accreditation purposes. For example, the AU count for the model yields a minimum of 1,850 AUs, which, if the model is acceptable, would then specify the minimum number of AUs.

If we turn the specifications for the mix of curriculum components back into relative percentages, then an institution would be free to use the curriculum measurement which it considers most appropriate for its engineering programs. The reference length must be taken relative to an equivalent minimum length so any additional program requirements above the minimum would be considered unspecified additional content.

Both these measurement approaches allow an institution to use measures of student-learning time, contact time, or other academic measures as appropriate without changing the fundamental requirements of the existing criteria.

8. Recommendations

1. Consult with regulators and other stakeholder groups to consider reducing the minimum program total in criterion 3.4.6 from 1,950 to 1,850 AUs.

    - Can the model program schedule proposed in section 6.1 be considered an adequate minimum for an engineering program for accreditation purposes?

2. Consult with HEIs, regulators, and other stakeholder groups to consider replacing the AU definition for the minimum curriculum elements in criteria 3.4.2–3.4.5 with the percentages from section 6.2.

    - Does this added flexibility in determining the mix of curriculum elements address concerns raised by the HEIs regarding the use of the AU as the sole measure of curriculum content?
    - Would the regulators have confidence that all students from any program in compliance with the new criteria would be satisfactory for licensure?
    - Does the use of percentages in specifying what is an acceptable engineering program help in the assessment of non-CEAB applicants for licensure?
    - Are there further concerns or issues that such a change would raise?

3. Perform an analysis with HEIs that use student-learning time in their definition of academic credit to consider establishing a learning time specification as an alternative minimum program total for criterion 3.4.6.

    - Can the LU as proposed by the AU Task Force be used as an alternative measure for the minimum program length?
    - Are there HEIs other than those mentioned in section 5.1 that also incorporate student learning time in their definition of academic credit?
    - Is the proposed equivalency of 1 AU = 2.5 LUs consistent with existing programs whose institutions have incorporated student learning time in their definition of academic credit?
    - Is there a minimum learning time specification that can be used in criterion 3.4.6 that is consistent across currently accredited programs at these various institutions?
    - Can the model program schedule in section 6.1 be used as a reference for establishing such a minimum?
    - Are there further concerns or issues that such a change would raise?