An Engineering Accreditation Management System

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Abstract

We have developed a web-based system to assist in the management of the engineering accreditation process. It provides a centralized tool for curriculum analysis, course and instructor database management, program information collection and tracking, report preparation, and graduate attribute planning and monitoring.

1 Introduction

The accreditation process [1] under the Canadian Engineering Accreditation Board (CEAB) is extremely thorough and time-consuming, involving a multi-year timeframe and the exhaustive collection, organization and analysis of information. We crudely estimate that the last review of the University of Alberta's (UofA) nine programs required the collection of more than a tonne of documents and consumed approximately 16,000 h in preparation time involving a personnel cost of well over \$1M. Further, the people most tied up in these preparations are the Faculty's senior leadership who are thereby unable to advance the strategic and operational objectives of the organization. Hence, there is a tremendous potential benefit of a system that would help simplify the task of managing engineering accreditation.

Meeting this challenge is compounded by recent CEAB changes to link instruction of engineering content with professional licensure through the so-called Qualified Accreditation Units (AU's). This means that relatively static program curricula must be linked with much more dynamic annual teaching assignments in order to demonstrate compliance. However, the 2008 introduction of the twelve graduate attributes and the requirement to implement a system to measure and continuously improve graduate outcomes will have the most significant impact on how Canadian faculties of engineering respond to accreditation requirements. This is very similar to the ABET process [2] employed in the United States,

which has posed a significant adjustment to American schools over the last decade. It also means that accreditation is no longer an episodic task undertaken once every six years, but is now an ongoing continuous activity.

In response to these challenges, the UofA has partnered with educational resource company Castle Rock Research Corporation [3] to develop a web-based software tool to greatly simplify the task of collecting, analyzing and presenting the information necessary to demonstrate compliance with the CEAB requirements. We call this the Accreditation Management System (AMS).

2 Requirements of the AMS

Clearly, one of the requirements of the AMS will be to analyze curricula to ensure that CEAB minima are being met in all categories. Traditionally, this has been done using spreadsheets. With elective streams and options, at the UofA there are 30 separate program specifications that must be analyzed across four departments. This is extremely difficult to maintain consistently using spreadsheets, especially with the recent Qualified AU's where the teaching assignment for a service course in one department will impact the accreditation in another. Hence, one main requirement is that a single centralized database be used to hold all course, instructor and program information so that consistency of data and approach can be maintained across the faculty. For reasons of privacy protection, that database must sit behind a firewall within the institution's own network. Nonetheless, that data must be easy to enter, modify, review, and track.

Further, we would like the application to be available to a wide range of administrators and instructors so that tasks and responsibilities can be distributed to the appropriate level. This necessitates a web-based user interface so that there is no requirement for specialized software to be deployed and maintained at the desktop. With a multiuser approach also comes a need for access control (id and

password) and varying user privileges based on their respective roles. This, along with an audit tracker, will help ensure the integrity of the data. The distributed, multiuser approach also mandates a robust system with an intuitive user interface along with online help to ensure infrequent users can be productive and not frustrated.

Of course, the AMS system must meet the needs of the CEAB reporting. Along with curriculum analysis, that means generating course information sheets, instructor CV's, licensure summaries, course content summaries, curriculum committee lists, resource summaries, etc. In all, there are ~30 different tables and forms required in a CEAB report that should be generated by the AMS system in the correct format.

One important area for which CEAB has not yet specified how to report relates to graduate attributes. Taking an approach similar to that typically used for ABET reporting, for each of the twelve attributes, the AMS system should provide a framework for generating curriculum maps, specifying performance indicators, scheduling and inputting measurement data, recording analysis results, and generating archival reports to document an overall continuous improvement process. This topic will be discussed further in section 4.6.

3 Implementation of the AMS

Levering the capabilities and expertise of Castle Rock, the AMS Solution implemented using the C# language within the Microsoft .NET framework. Database services are provided under SQL, web services under IIS and Apache Tomcat and content management using an in-house tool developed by Castle Rock. The full set of software needed is listed below:

- Windows Server 2008 R2
- Microsoft SQL Server 2005
- Apache Tomcat
- IIS 7
- ASP.NET 3.5

The hardware required to run the AMS application consists of a Windows Server 2008 R2 based system with a dual core processor and 4GB of memory. Storage requirements vary with data needs, but would typically be met by ~1TB for a large, multi-program institution.

4 Capabilities

The current capabilities of the AMS system are demonstrated in the sections below.

4.1 User Roles

Within the AMS system, there are a variety of roles a user can be assigned. Faculty Admin users have the highest privileges and can access any data or create/delete any kind of user. Typical Faculty Admin users would be Associate Deans or others coordinating at the Faculty level. Department Admin users have authority only within their own unit in which they can create or modify programs or courses, or create Instructor or other Department Admin users. They would also make teaching assignments and review accreditation checklists. Typically, these would be Chairs, Associate Chairs, and senior departmental administrators. Most users of the AMS would be Instructors who can access only their assigned courses and modify their own personal data and CV's. This hierarchical structure ensures appropriate access to sensitive information and minimizes the chance of inadvertent corruption of data. Of course, all users are authenticated by a password and transactions are logged for review if problems arise.

4.2 Course Information

The biggest single source of data for the AMS relates to courses. At the UofA, we have almost 500 courses relevant to our undergraduate programs. Each requires all of the information needed to generate a CEAB course information sheet, including the breakdown of AU's into the various categories (Math, Natural Sciences, Complementary Studies, Engineering Science, Engineering Design, Other), plus the list of instructors, plus various content from the course (syllabus, notes, exams, labs, graded student work, web pages, etc.) that can be uploaded to form a repository for future reference as well as to satisfy program visitors before and during their visit.

Within the AMS, the main page for entering course information is as shown in Figure 1. Tabs along the left hand side allow the user to jump to different sections to review or enter course information. An index page allows navigation between courses and can be sorted by faculty and department or searched based on course number or title. A teaching assignment page allows the selection of instructors within a department with regard to their PEng status and the needs of the course in the context of Qualified AU's.

Course data can also be imported from a comma-separated value (CSV) file of text data. This allows much of the course information to be input directly from reports generated by existing academic information systems. Course data is associated with a given Academic Year, and most of it automatically rolls forward when a new Academic Year is created.

Figure 1. Main page for course data entry.

Gathering course information and ensuring it is complete is a major, tedious task when preparing for a CEAB visit. To assist in this, the AMS system provides a checklist functionality to review what has been input and uploaded onto the system. An example checklist is shown in Figure 2.

Course Title	Course Number	Course Outline	Graded Assignments	Graded Exams	Graded Labs/Reports	Institutional Materials	Other
Acoustics And Noise Control	MEC E 553	0	0	0	1	0	0
Adapting Tech Societal Needs	ENG H 406	0	0	1	0	1	0
Adv Civ Eng Topics	CH E 504	0	0	1	1	0	0
Adv Environmental Eng II	ENV E 401	0	0	0	0	0	0
Adv Materials Eng & Applied Dev	MAT 503	0	0	0	0	0	0
Adv Strength Of Materials I	MEC E 380	0	0	0	1	1	1
Adv Strength Of Materials II	MEC E 480	0	1	0	0	0	0
Adv Topics Proc Dev & Control	CH E 506	1	1	0	0	1	1

Figure 2. Example checklist page for tracking course information.

4.3 Instructor Information

Within the Faculty of Engineering at the UofA, there are almost 250 individuals involved in instruction. Their credentials and status must be recorded, particularly to be able to track Qualified AU's and generate CV's and other CEAB tabular reports. This information is typically input by the Instructor who can also upload a CV in PDF format. Figure 3 shows the main Instructor information page. As with the course information page, there are tabs along the left side that allow quick navigation to enter specific information. As well, there is a CV status page that Admin users can use to review which Instructors have completed the entry process.

Figure 3. Main page for instructor information entry.

4.4 Program Information

A key component of CEAB accreditation is a quantitative 'minimum path' analysis of the program curriculum against a number of content requirements. This requires specification of common core, program compulsory, option compulsory and elective courses. This specification is typically done by a Department or Faculty Admin user via the Program Builder page shown in Figure 4. Tabs near the top allow navigation through the different categories (e.g. program compulsory) and tables at the top track the AU's accumulated in each of the content types. Electives are specified in groups with selection rules such as "choose two out of the following..."

Course Title	Course Number	Course Outline	Graded Assignments	Graded Exams	Graded Labs/Reports	Institutional Materials	Other
Acoustics And Noise Control	MEC E 553	0	0	0	1	0	0
Adapting Tech Societal Needs	ENG H 406	0	0	1	0	1	0
Adv Civ Eng Topics	CH E 504	0	0	1	1	0	0
Adv Environmental Eng II	ENV E 401	0	0	0	0	0	0
Adv Materials Eng & Applied Dev	MAT 503	0	0	0	0	0	0
Adv Strength Of Materials I	MEC E 380	0	0	0	1	1	1
Adv Strength Of Materials II	MEC E 480	0	1	0	0	0	0
Adv Topics Proc Dev & Control	CH E 506	1	1	0	0	1	1

Figure 4. Program Builder page for specifying the courses required for a given program or option.

Reports on the program AU content can be selected from a list allowing assessment at different levels of detail. Qualified AU's are displayed at this level. These consider the licensure status when counting Engineering Science (ES) and Engineering Design (ED) content. Under recent CEAB rules, ED only counts towards Qualified ED AU's if it is being taught by an instructor with a PEng. ES only counts towards the Qualified ES+ED total if it is taught by a PEng or a recent hire (within 5 years) actively pursuing registration [4]. Hence, program totals must link into instructor assignments and instructor

qualifications and appointment date for determining these totals. Of course, the minimum path principle applies here, so if multiple sections exist, only the least qualified instructor counts towards this calculation. This highlights the need to carefully consider program AU totals when making teaching assignments.

As well, program specific information such as staff changes, contents summaries, enrolment data, transcripts or expenditures can be input and reviewed within these program reports.

A quick summary of curriculum content for all programs can be found on the main program management page. Figure 5 shows an example with multiple programs and options. Values are colour coded as green (compliant with CEAB requirements), yellow (over the minimum but by less than 10%) or red (under CEAB minimum).

Figure 5. Main program management page with a summary of curriculum totals.

4.5 CEAB Reports

The purpose of the AMS is to facilitate accreditation. Hence, it should generate reports in the format expected by CEAB. In addition to the instructor CV's and course information sheets, the AMS system currently generates the CEAB tables listed below. This is basically all of the mandatory tables in the questionnaire. They are generated on a program-by-program basis in PDF format.

Table 1. List of CEAB tables generated by the AMS.

AMS generates the following reports, as defined by the CEAB Questionnaire:

3.3.3.1: Mathematics Content Summary	5.2	Academic staff information sheet
3.3.3.2: Natural Science Content Summary	5.3	Summary of Staff Changes
3.3.4a: Summary of Engineering Science and Engineering Design AU	5.4	Summary of Expenditures
3.3.4b: Licensee Status of Instructors Delivering Engineering Science and Engineering Design AU	5.5	Enrolment and Degree Data
3.3.5.1: Complementary Studies Content Summary	5.6a	Summary of Transcript
3.3.6: Summary of AU Content for Each Program and/or Option	5.7a	Course information sheet
3.3.7: Laboratory Experience	5.8a	Compulsory Common Core Courses
3.4.2.1: Faculty Qualifications and Experience	5.8b	Program-Compulsory Courses
3.4.3: Officers Responsible for Engineering Department and Program	5.8c	Option-Compulsory Courses
3.4.8: Curriculum Committee Members	5.8d	Elective Courses
5.1a: Summary of Academic Staff Holding Continuing Appointments	5.8e	Program Totals
5.1b: Summary of Academic Staff Not Holding Continuing Appointments	5.8e	Program Totals

4.6 Graduate Attributes

Since 2008, CEAB has introduced the additional requirement that programs demonstrate that their students possess certain attributes at the time of graduation. These attributes are listed in Table 2. Furthermore, these attributes are to be measured as part of a continuous improvement process, necessitating a systematic approach. Such a process can be greatly facilitated by a system like the AMS.

Table 2. CEAB graduate attributes

1	Knowledge Base	7	Communication skills
2	Problem Analysis	8	Professionalism
3	Investigation	9	Society & Environment
4	Design	10	Ethics and Equity
5	Engineering Tools	11	Economics
6	Team Work	12	Lifelong Learning

The CEAB has not at this time defined a standard approach for implementing a graduate attribute process. Groups such as the EGAD project [5] sponsored by the National Council of Deans of Engineering and Applied Sciences have developed some resources to facilitate this task, and the ABET system provides a model that can be emulated.

Borrowing from the ABET model, the UofA has developed an approach that employs a number of performance indicators (PI's) for each of the 12 graduate attributes. These are not intended to be exhaustive measures of the attribute, but provide an indication of whether the requisite characteristics associated with the attribute have been developed. These PI's are to be objectively measurable and usually associated with a rubric defining levels of achievement. As an example, a subset of the PI's and rubrics developed by the UofA for its Communication Skills attribute is presented in Figure 6.

Aspect	Performance Indicator	Measure	Unsatisfactory 1	Developing 2	Satisfactory 3	Excellent 4
Organized message	Presents information in an organized fashion	ENGL 199 technical report	Thesis unclear and supporting arguments poorly organized	Thesis clear but supporting arguments not clearly made	Conclusions clear and logically supported	Conclusions clear and compellingly presented
Writing	Uses proper grammar and punctuation	ENGL 199 technical report	Contains numerous grammatical errors	Contains some grammatical errors	No more than 3 grammatical errors per page	Absent or grammatical errors
	Uses language effectively	ENGL 199 technical report	Employs colloquial expressions, imprecise word choices, simple concepts	Infernal style, contains jargon, flows reasonably well between concepts, some imprecise word use	Vocabulary, style and complexity of thought appropriate for the main audience	Engaging, interesting to read for all intended audiences
Speaking	Prepares and delivers an effective oral presentation	CH E 464 - oral presentation	Stumbles frequently, forgets points, or is inaudible	Is sometimes unclear or loses the thread of sentence	Speaks clearly and confidently with a message that is easily understood	Captivating speaker with points persuasively delivered
Use of graphics	Makes effective use of graphical elements to support message	CH E 464 - final report	Graphical elements poorly conceived, illegible and confusing	Figures present information, but audience has to struggle to interpret	Figures clearly present desired content in an unambiguous manner	Figures compelling and clear

Figure 6. Partial set of performance indicators for the Communication Skills graduate attribute.

The AMS system provides a framework for specifying the PI's and associated courses, rubrics and targets. These, of course, will depend on the program. Based on course information, the AMS can generate a map showing where and the degree to which the

attributes are developed across the curriculum. This assists in choosing courses in which measurements can be taken. (See Figure 7) Further, it can provide a process for scheduling when and who will perform the assessments. Measured data can be analyzed and recommendations recorded in a systematic manner. These outcomes can be captured in a report that documents the continuous improvement process. Figure 8 shows a model of such a report with multiyear data for various PI's related to the Team Work attribute.

Course Title	Course Number	K2	PA	2a	2b	2c	ST	TW	Cu	IV	Sk	SS	EPI	LL
Human Anatomy and Physiology: Cells and Tissues	BIOL 201													
Human Anatomy and Physiology: Systems	BIOL 202													
Engineering Thermodynamics	MECH 201	2												
Heat Transfer	MECH 202	2	2	2	2	2								
Heat Transfer	MECH 203	2	2	2	2	2								
Chemical Engineering Thermodynamics	CHBE 201	2	2	2	2	2								
Chemical Engineering Thermodynamics	CHBE 202	2	2	2	2	2								
Chemical Engineering Lab	CHBE 203	2	2	2	2	2								
Chemical Engineering Lab	CHBE 204	2	2	2	2	2								
Chemical Engineering Lab	CHBE 205	2	2	2	2	2								
Chemical Engineering Lab	CHBE 206	2	2	2	2	2								
Chemical Engineering Lab	CHBE 207	2	2	2	2	2								
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Figure 7. Attribute map showing the degree each of the 12 attributes are developed in each of the courses in a program.

Figure 8. Model report for the Team Work attribute showing the schedule for measuring the individual PI's along with the current date, multiyear trends against the target performance, along with the outcomes of the analysis.

5 Conclusions