Comparative Analysis of Engineering Curricula for Alignment with 21st Century Engineering Practices

Anita Lazurko, Patrick Miller, Dena Ghoneim,
Engineers Without Borders Canada - Global Engineering Venture
anitalazurko@ewb.ca, denaghoneim@ewb.ca, patrickmiller@ewb.ca

Abstract – *The vast engineering challenges of the 21st century and the unique position of engineers as decision makers, conveners, and influencers has created a need for a directional shift in the content and teaching methods used in Canadian engineering education.*

Both Canadian and international universities were evaluated based on nine criteria deemed relevant and important to the evolution of engineering education by Engineers Without Borders Canada. These include overall vision and direction of the engineering faculty and university, interdisciplinary opportunities, leadership programs and recognition, topics in technology and society, innovation in curriculum content or delivery, a growing understanding of globalization, cross cultural communication and project management, and a direct connection between work experience and curriculum.

Results have shown that many Canadian universities are strong overall, while some universities have strengths in a few areas. These results can be utilized and shared as best practices. The international program evaluation showed very diverse results, some of which can be adapted and utilized in Canadian engineering curriculum. These results can be employed as many entities collectively move forward to develop and reinvent engineering education in the 21st century.

Keywords: 21st century engineering, curriculum evaluation, interdisciplinary, leadership, diversity, innovation, globalization, communication, project management

1. INTRODUCTION

The engineering challenges of the 21st century have created the need for significant changes in both the content of engineering curriculum and the methods by which they are taught. Engineers play many major roles in society as decision makers, influencers, and conveners, and therefore there is an impetus to complement the traditional technical curriculum with new 21st century knowledge and skills [1].

Engineers Without Borders (EWB) Canada defines global engineers as engineers that are equipped to lead

within their communities and the profession in the 21st century. Global Engineering is EWB's collaborative program to encourage and support the development of a new generation of engineering graduates who are ready to practice in a globalized 21st century environment. These graduates have taken part in innovative educational experiences that have tempered their leadership skills, expanded their problem solving ability, and developed a global awareness that, along with their engineering technical excellence, will enable them to go beyond engineering and play a leading role in Canada and on the world stage in the 21st Century. In particular, EWB's vision for global engineering is grounded in four principles:

- Awareness of globalization and its impact on engineering practice
- Capability of practicing leadership and interdisciplinary skills
- Competency in exploring the engineering profession's role in complex societal issues and
- Ability to apply technical skills in a global context

This paper first sets out a framework for assessing the degree to which schools provide a 21st century learning environment and then applies the framework to Canadian and International engineering schools to provide a high level analysis of trends in education. The analysis of engineering curriculum at a Canadian and international level provides the opportunity to assess where core strengths lie in delivering innovative engineering education in order to share best practices with Canadian universities. This assessment can be used for organizations, like EWB, as well as other educational institutions to share best practices and identify areas for further inquiry and development.

Universities were evaluated based on their alignment with 21st century engineering practices. Each school was ranked based on nine criteria deemed important to global engineering and engineering practice in the 21st century. These include overall vision and direction of the engineering faculty, topics relating engineering and society, opportunities for interdisciplinary learning and

project work, programs and recognition for leadership growth, diversity of research including topics connecting technical engineering to society, innovation in the engineering curriculum, topics relating technical advancement and globalization, an emphasis on communication and project management including cross cultural communication, and opportunities for work experience that directly connects to an overall curriculum design. [1]

The analysis of Canadian schools highlights opportunities for greater best practice sharing - both nationally and internationally. While many schools have core strengths in one or a few criteria, only a small selection of Canadian schools had overall strong results. The analysis of international engineering programs, which was broken down by nation and region, demonstrated diverse results. While some schools offered overall strong programs, others showed overall poorer performance. These two analyses demonstrate an evaluation program based on the 9 criteria while also providing a platform for further discussion about how curricular programs can deliver 21st century skill-sets and knowledge to engineering students.

2. Education Evaluation

2.1 Evaluation Background

The evaluation process is composed of nine criteria identified by EWB through holding forums on engineering education, experience and collaboration on curriculum development and delivery with universities across Canada. These criteria are seen as principles that enhance engineering education to provide a quality learning environment for 21st century engineering students. The framework that utilizes this set of criteria was developed in 2013 as part of ongoing research into engineering education by the Global Engineering Venture in Engineers Without Borders Canada.

2.1.1 Overall Vision and Direction

This criterion evaluates the presence of an overall vision and direction that recognizes the need for a new kind of engineering education as one of the key mandates of the institution. This should include at least three of the following elements: globalization, innovation, commitment to the betterment of society, engineering for the 21st century, systems thinking, multidisciplinary skills, and communication.

2.1.2 Focus on Engineering and Society

This criterion recognizes universities which incorporate topics of social, economic, and environmental sustainability and the role of engineers in society into the

core curriculum and/or offer them as topics of instruction in specific courses or areas of concentration.

2.1.3 Focus on Interdisciplinary Design and Project Work

Universities that score high on this criterion integrate interdisciplinary work throughout all four years of an engineering degree, as evident in classroom assignments, projects, and other learning environments. Interdisciplinary work is included between engineering departments, and across university faculties.

2.1.4 Leadership Growth and Recognition

This criterion indicates the significant investment in staff, time, money, and student space in allowing students to gain significant experience outside of the classroom, and a way of measuring and recognizing those extracurricular achievements (specific to engineering).

2.1.5 Diversity of Research

This criterion evaluates if engineering departments have well established research mandates that reflect societal needs, and the degree to which faculty are actively engaged in applying their research to 21st century challenges. This also evaluates if the university is on the cutting edge of researching engineering education. This is indicated by the existence of more than one professor doing any two of the following: exploring engineering education, studying the relationship between engineering, society, globalization, and environmental sustainability, uses technical engineering practice to contribute to society

2.1.6 Innovation

This criterion evaluates which institutions have both innovative curriculum content and delivery methods executed in more than one aspect of the engineering curriculum. A significant indicator is a research focus in innovative engineering education.

2.1.7 Globalization

Universities that score high on this criterion deliver a curriculum that has a strong emphasis on globalization and the effect it will have on engineers today, including mandatory courses and/or optional specializations, minors, certificates, and study abroad opportunities.

2.1.8 Communication and Project Management

This criterion evaluates the degree to which students are exposed to a wide range of communication and project management skills and are given the opportunity to apply them in real world situations

2.1.9 Work Experience

Top universities in this category offer programs in which over 75% of students gain industry experience, with the support of their institution, along with support throughout the experience in the form of a course or other learning tool.

2.2 Audit Research Methods

Due to the timeline and scope of this project, the bulk of research was conducted based on a document and policy review using documents publically available on each institution's website. Programs that achieved high audit results were pursued more directly with follow up interviews and questionnaires to staff and faculty. This research focused on assessing the presence of factors associated with criteria but did not address the outcomes of educational programs, which will be analyzed in follow up research.

2.2.1 Assumptions

This research was guided by a number of assumptions in order to frame and conduct the research in a timely manner. These assumptions are:

- Courses, programs, etc. offered at institutions have a level of quality of execution that gives them some degree of effectiveness and benefit to students if they are offered – quality of courses were not individually assessed.
- Information provided through formal university materials accurately represents the intentions and operations of the institution
- An objective understanding of the university's various characteristics can be extracted from the institution's materials

2.2.2 Criteria Framework

As this framework deals with qualitative data, a reference based system of grading each criterion was developed in order to standardize results between institutions. The evaluation criteria were used on a five point scale defined in table 2.1:

Table 2.1: Evaluation Criteria

Criterion	Highest (5)	Lowest (1)
Overall Vision and Direction	Recognizes the need for a new kind of engineering education as the KEY mandate of the institution. This new kind of engineering education, in the context of vision and direction, should include at least 3 of the following elements (in some form): global thinking/globalization, innovation, commitment to benefit society, engineer for the 21st century, systems thinking,	Institution's vision for engineering education does not focus on the above list.

	multidisciplinary skills and opportunities, commitment to graduate engineers with communication skills for today's world	
Engineering and Society	Social, economic, and environmental sustainability, along with the role of engineers in society, are integrated into the core curriculum and/or are offered as topics of instruction in specific courses alongside the potential opportunity to pursue relevant topics as areas of concentration	The institution has not integrated sustainability into its core curriculum or established specific courses of instruction.
Interdisciplinary Design and Project Work	Interdisciplinary work is integrated throughout all four years of engineering degree and is evident in classroom assignments, projects, and learning environments. Engineering students have many opportunities to interact with other disciplines of engineering and other faculties while pursuing their education.	Interdisciplinary opportunities are limited throughout formal education programs and students do not collaborate across discipline or faculty boundaries
Leadership Growth and Recognition	Evidence of significant investment in staff, time, money, and student space in allowing students to gain significant experience outside of the classroom, accompanied by a way of measuring and recognizing those extracurricular achievements (specific to engineering)	Student space and small amounts of funding are available, but no other support is provided.
Diversity of Research	Engineering departments have well established research mandates that reflect societal needs and faculty are actively engaged in applying their research to 21st century challenges and/or the university is on the cutting edge of researching engineering education. This is indicated by the existence of more than one professor doing any two of the following: (1) exploring engineering education, (2) studying the relationship between engineering, society, globalization, and environmental sustainability, (3) uses technical engineering practice to contribute to society	Department mandates and/or faculty research programs are not clearly linked to societal issues or 21st century challenges
Innovation	The institution has both innovative curriculum content and delivery methods executed in more than one aspect of the engineering curriculum. A significant indicator is a research focus on innovative engineering education.	The institution has a traditional engineering curriculum with no apparent vision or strategy for innovation.
Globalization	Curriculum has a strong emphasis on globalization and	Globalization is not integrated

	the effect it will have on engineers today including mandatory courses and/or optional specializations, minors, certificates, study abroad opportunities, etc.	into the core curriculum or offered in faculty specific specialized courses.
Communication and Project Management	Students are exposed to a wide range of communication and project management skills and are given the opportunity to apply them in real world situations	Students are not exposed to these topics.
Work Experience	Over 75% of students gain industry experience with the support of their institution, along with support throughout the experience in the form of a course or other learning tool	No formalized work, internship, or co-op program has been developed

3. RESULTS AND DISCUSSION

This section of the paper outlines best practices that were identified in the engineering education audit. This paper focuses on best practice sharing in order to further research into 21st century engineering education by non profits and universities, while other practices identified in this research project will be outlined in future papers.

3.1 Canadian Engineering Education Audit

3.1.1 Overall Vision and Direction

The universities with the strongest overall vision and direction have many of the same qualities. All of the universities have several guiding statements in their long term strategies, policies, and plans that are aligned with the global engineering concept. Many of them have visions or mission statements that directly reference their goals to educate globally responsible professionals, as well as direction for how they will achieve their goals. A triple bottom line framework including environmental, social, and/or economic sustainability was used to clearly articulate direction and vision in a number of cases.

Throughout the majority of institutions reviewed, there is an emphasis on integrity, ethical conduct, and the responsibility of the engineering profession to benefit society; either through educating future engineers or conducting innovative research. There are common themes of social relevance and real world problems. Each institution does not contain all of these themes, but reflects some of them prominently.

A notable example of a high ranking vision is McMaster's, which reads, "... *known internationally as a leader in research and education supporting the development of engineering practices for a sustainable world...*", and McMaster defines sustainability as, "*the*

application of engineering in a socially responsible manner".

3.1.2 Focus on Engineering and Society

The universities with the highest ranking in the engineering and society criterion have a number of common characteristics. The main metrics are quantity and diversity of course content and programs related to the intersection of engineering and society. There is also consideration of the structure of programs and their accommodation of these classes. Other criteria outside of courses include certificate programs, Engineering & Society themed double majors or specializations, and leadership & social awareness programs.

3.1.3 Focus on Interdisciplinary Design and Project Work

Universities are categorized as high on this criterion because of the diversity of ways a curriculum with an interdisciplinary and project-based learning approach is implemented. These universities often show a commitment to this concept through their overall vision and direction.

Most universities have a first year design and/or communications course that brings all first year students together. The outstanding universities use community service learning and acquire real-world clients for their students, starting in first year, extending through to fourth year. Some universities use these real-world projects to demonstrate the societal implications of design.

These universities continue to offer explicitly multidisciplinary or interdisciplinary opportunities throughout the entire engineering degree, culminating in a final capstone project that can be done as an interdisciplinary project. Students have the opportunity to take courses on engineering design and engineering innovation.

The high-ranking universities tend to have partnerships with other faculties (business, medicine, law, etc.) and offer specializations, options, or double degrees that allow students to work alongside non-engineers.

3.1.4 Leadership Growth and Recognition

The universities that rank highest in this category have both of two main criteria: strong engineering leadership programs to promote leadership growth and scholarships awarded based on non-academic criteria to recognize and encourage engineering leadership.

The leadership programs or certificates contribute to a higher ranking if they are offered directly by the faculty of engineering and/or are offered specifically to improve *engineering* leadership on campuses. The scholarships

are ranked highest if they have a very direct focus on extracurricular involvement, community service, and leadership. Some of these universities also offer mentorship programs, co-curricular records, and/or leadership workshops.

3.1.5 Diversity of Research

The defined indicators for this criterion are universities with more than one focus area in the following categories:

- Engineering education
- Relationship between engineering, society, globalization, and/or sustainability
- Using technical practice to contribute to a benefit to society

These are explored using research focus areas that are either chosen strategically (from the strategic plan or equivalent) or seem to happen because of professor interest (from faculty summaries). Common focus areas include:

- Green/renewable energy and environmental sustainability
- Communication networks
- Biomedical technology and human mobility
- Integrated learning and innovative engineering education

These focus areas seem to have an obvious societal impact, however many other research areas are highly technical and have a significant societal impact.

3.1.6 Innovation

These universities are ranked based on innovation within the engineering curriculum itself. These innovations are identified by their unique approach that contrasts traditional engineering education, and moves toward a more holistic educational experience. The universities that are ranked highest have multiple areas of innovation. Some of these areas of innovation include:

- Multidisciplinary design projects and courses
- Industry involvement in curriculum through long term client-student project partnerships and guest lectures
- Professional and career development courses
- Curriculum and international practicum partnerships for valuable global experience
- Specializations or combined degrees that are completely outside of the engineering field but still very relevant

Many of these innovations are made possible by strong partnerships between engineering faculties and other faculties both in both within universities and internationally.

3.1.7 Globalization

This criterion is defined as a focus on globalization, cultural awareness, and international opportunities. The highest scoring universities approach these topics from many different directions. This criterion has some overlap with the focus on engineering and society, but a high ranking in this category directly indicates an international focus.

The high ranking universities offer some sort of Global Engineering or International/Social Development Certificate. They offer unique courses that cover topics like innovation in global systems, energy futures abroad, technology, engineering, and global development, and appropriate technology. Many of these courses are related to an optional practicum in a developing nation. These universities seem to encourage international opportunities, like studies or internships abroad, and some offer opportunities to put a major focus on international studies, such as a double degree in Engineering and International Studies.

3.1.8 Communication and Project Management

The universities that rank the highest in communication and project management offer experiences beyond the traditional engineering degree requirements. Most universities offer one or two communications courses, which are sometimes integrated into a design and communications course. The universities in the highest category offer these plus unique, additional options.

Some topics included in these additional options are problem solving, technical communication, construction management, language and meaning, representing science and technology in popular media, effective leadership, understanding groups and organizations, policy, project finance, and more.

These universities usually offer options or specializations related to communications and project management. For example, McMaster University offers an Engineering & Management 5-Year Program, which allows students to graduate with one year credit towards an M.Ba.at McMaster University.

3.1.9 Work Experience

The universities ranking the highest in the work experience criterion have an established internship or co-op program. They must have a component of the curriculum that relates directly to their work experience; to prepare them for and/or to capture and learn from their experience.

The topics included in these curricular pieces include interviewing, resume preparation, work performance, career planning, and engineering leadership. Some of

these are taken before internship, and some taken as online courses during the work placement.

Some programs (especially co-op) require a detailed work experience summary at the end of the work term, which includes lessons learned and case studies. Some programs, like the University of Victoria, have a mandatory co-op program, and seem to have a more diverse and rooted support program to accompany it.

Table 3.1: Canadian Universities ranked by 9 metrics

Criterion	1	2	3	4	5	6	7	8	9	Total
U of T	5	5	4	5	4	5	5	5	4	42
Lassonde	5	5	5	4	5	5	4	4	4	41
Queen's	5	4	5	3	5	5	3	4	5	39
UBC	5	5	4	3	5	4	4	3	4	37
McMaster	5	5	3	4	4	3	4	5	4	36
Western	4	4	4	3	5	4	4	3	4	35
U of C*	4	3	2	5	4	3	3	4	4	32
UVic	3	3	3	3	4	5	2	3	5	31
Waterloo	4	3	2	3	5	3	2	4	5	31
McGill	2	4	3	2	4	3	3	3	4	28
Concordia	5	4	2	2	5	3	2	2	3	28
U of S	3	3	2	3	5	2	2	3	4	27
SFU	4	3	3	2	3	2	2	4	4	27
U of G	4	2	3	2	4	3	3	2	2	25
Memorial	1	4	2	3	2	3	2	3	4	24
UNB	3	2	4	1	3	2	2	3	3	23
Ryerson	4	2	2	2	4	1	2	2	3	22
U of A	2	3	x	3	4	2	1	x	4	21
Carleton	2	2	2	3	4	2	1	2	3	21
U of O	2	2	2	1	5	2	2	2	3	21
Dalhousie	3	2	2	2	2	2	2	2	2	19
Windsor	3	3	2	2	2	1	2	2	2	19

x indicates no information was available

*It should be noted that the authors of this paper are graduates of the University of Calgary

3.2 International Engineering Education Audit

3.2.1 Overall Vision and Direction

Universities ranked high in this category have many statements related to global engineering concepts, frequently communicated by some key words. These statements include the opportunity for engineers to contribute to society through a number of avenues, acknowledgement of the role of engineers in shaping our world, and an engineer's role in the betterment of humanity. These institutions claim their engineers will seek solutions to the most difficult challenges of our day. Key words include visionary thinking, leadership, creativity, entrepreneurialism, philanthropy, and 21st century.

3.2.2 Focus on Engineering and Society

These universities generally offer a wide range of courses related to engineering and society with a high level of accommodation and flexibility in scheduling. Many have several mandatory language and culture courses and devote a higher percentage of curriculum to humanities, social sciences, language, culture, and engineering and society courses.

Some engineering education systems, such as University of Tokyo, have multiple (2) years of general sciences, mathematics, humanities, social sciences, language, and culture courses before multiple (2) years of engineering courses. Other regions require both a 3-year Bachelor's and 2-year Master's to become a professional engineer, and thus have more scheduling flexibility for additional engineering and society courses.

These universities have innovative institutes to support these topics and offer unique programs related to engineering and society. An example at the University of Tokyo is an institute devoted to researching and implementing global engineering and societal context into engineering education. Other universities host lecture series on relevant topics that reach world leaders on engineering education. Several of these universities have departments dedicated to delivering a degree program directly related to engineering and society.

3.2.3 Focus on Interdisciplinary Design and Project Work

These universities generally offer significantly more frequent opportunities for design and project work and incorporate significantly more opportunities to participate in interdisciplinary projects or courses. These come in the form of frequent project courses and multidisciplinary senior capstone projects. Several courses related to the design process and working in interdisciplinary groups are also offered.

These universities incorporate projects and interdisciplinary work in innovative ways. Flexible Degree Programs allow students to graduate with a Bachelor of Engineering unassociated with a department, so students have the flexibility to take courses and gain experience in any department. Integrated Course Blocks require first year students to combine the study of two subject areas in two separate classes with a unifying project. Double degrees and specializations allow students to study an interdisciplinary subject of interest alongside an engineering degree.

Many of these engineering faculties have very strong ties to other faculties at their universities, including professional faculties. These partnerships extend beyond collaborative research into a very integrated engineering curriculum.

3.2.4 Leadership Growth and Recognition

These universities have placed strong emphasis on increasing the leadership capacity of their graduates. They have well established leadership programs that are specific to engineers. They provide a comprehensive list of scholarships and awards based on leadership growth, community service, and/or extracurricular involvement. These universities also tend to have institutes dedicated to either help fund and support students trying to further their entrepreneurial/leadership experiences or conduct research on engineering leadership and education. Some of these leading universities also have opportunities for leadership and professional development and co-curricular credit programs.

Some unique engineering leadership programs and/or initiatives include a very well established engineering leadership program at MIT, a one year intensive global leadership program at Kyoto University in Japan, and a three day period of lectures and professional development similar to TED, for first year engineering students, called the Intro to Advanced Engineering Leadership at Kyoto University.

3.2.5 Diversity of Research

These universities are mostly large universities with impressive diversity of engineering research. These universities usually host a mixture of traditional technical engineering research institutes and very innovative institutes whose mandates appear to benefit society and the world. Many also have technical research that has the potential to be applied to a host of problems and innovations that could benefit society. These research projects also have innovative, interdisciplinary, and flexible qualities.

Many of these universities have stated research goals, purposes, or focus areas, which usually mention the need to fulfill demand from the public and benefit the larger society.

Some innovative and diverse research topics include environment and energy, bioengineering for human health and environment, educating leaders, global learning and outreach, biomechanics, entrepreneurship and technology, social systems, innovation management, and other related topics.

Some top universities are collaborating very closely. Top universities in Japan have created the Global Centers of Excellence. The goal of this collaboration is to bring Japanese engineering research to the forefront of engineering research in the world by utilizing the best aspects of each of the universities and the interdisciplinary opportunities close collaboration can present.

3.2.6 Innovation

These universities have both an institute actively seeking innovations in engineering education and are actively implementing them. These universities host a diversity of innovations, many of which have far reaching positive reputations.

Some of these curriculum innovations relate to the structure of the engineering degree program. An example of this includes flexible engineering degree programs, total percentage of curriculum devoted to language, culture, humanities, social sciences, interdisciplinary projects, and design, unique minors, specializations, and double degrees, and third year group capstone design projects followed by major individual 4th year thesis projects.

The overall engineering degree structure also varies from region to region. For example, Japan hosts a two-year Junior division in general mathematics, language, sciences, humanities, and culture followed by two years of intensive engineering courses in Senior division. Some countries in Europe require a 3-year Bachelor of Engineering and 2-year Master of Engineering in order to practice as an engineer.

Some universities offer innovative degree programs, including Social Engineering, International Development Engineering, and a double degree in Civil Engineering and Architecture. Many of these innovative programs come from strong partnerships with other university Faculties. Interesting collaborations include a Diversity and Ethics Center, Medical School, Law School, and Business School.

There are innovations within the practical experience that students must receive to graduate as an engineer, including mandatory work placements, mandatory professional experiences, and others.

There are extra/co-curricular innovations as well. Examples include the Undergraduate Practice Opportunities Program at MIT. This program is a full year co-curricular program that prepares sophomores for real world engineering, the new OpenCourseWare trend that is making engineering courses accessible to a much more diverse set of individuals around the world, and mandatory lecture series meant to expose future engineers to the diversity of possibilities for future careers.

One of the most innovative themes across the board is the way different regions incorporate their culture and values into the curriculum. École Polytechnique puts very little value on research and specialized knowledge, but provides students with the knowledge and professional skills for civil service. Approximately 85% of Japanese engineers attend a Master's program, thus the curriculum provides enough specialized, technical knowledge to make that possible. They also seem to value globalization by providing their engineers with the ability to work anywhere in the world through language and culture. Chinese schools also have many mandatory classes related to both local and international languages, Chinese history, and culture.

3.2.7 Globalization

These universities offer a combination of opportunities that are both curricular and extracurricular. Examples of incorporation of globalization in the curriculum include courses directly related to globalization offered to all students, departments of Global Engineering or Global Learning, minors or specializations in culture or international or ability to add "with an international focus" on engineering degree, offering courses in multiple languages and requiring that students learn a second language, degrees in Social Engineering and International Development Engineering, and "Buddy Training and Intercultural Training" which creates a deeper level of empathy between international and local students and improves communication across cultures.

There is also a host of opportunities for students to gain international experience and thus a better understanding of the effect of globalization on their work as engineers. Examples include massive online open course systems that allow for more diversity in the engineering field, International Exchange programs that provide training and leadership growth, Global Engineering leadership conferences, institutes for research and innovation dedicated to improving lives all over the

world, and an International Certificate that gives recognition to students who have international experience but do not have the opportunity to do a semester abroad

The universities ranked in the top of this category have a collection of several initiatives from the lists above.

Some of these universities also have very deep partnerships with other faculties, which create opportunities to incorporate international concepts into curriculum not available within the engineering faculty.

3.2.8 Communication and Project Management

These universities incorporate a wide range of project management and communication courses. They are implemented in a number of different ways. These include communication requirements that apply both indirectly and directly to future work as an engineer. Some universities have a very strategic framework that takes students through an experience of communication, project management, and other soft skills training. Some universities have a very intensive and thorough project and design course structure which incorporates many of these aspects.

Specific courses offered depend heavily on the region. American and European countries focus on management, entrepreneurialism, and interdisciplinary thinking, while some Asian countries focus much more on communication across cultures.

These universities also tend to offer minors, specializations, or degree programs directly related to management or law. Some universities have their own Department of Management.

3.2.9 Work Experience

These universities offer sophisticated, usually mandatory, practical experience programs. Some also simultaneously offer job shadow and/or professional development programs. The top universities have incorporated their practical experience programs into their curriculums by making them mandatory and providing accompanying classes that are relevant to the work experience the student is receiving. The best programs have these strategically placed so the students' development is very intentional.

A unique aspect of the University of Sydney program is their mandatory 12-week practical experience and associated written report. If students are unable to find 12 full weeks of work, they can also use 4 weeks practical experience plus professional development events, industry based courses, and/or approved site visits.

6. REFERENCES

Table 3.2: Average Ranking of Universities by Region

Institution	1	2	3	4	5	6	7	8	9	Total
USA	4.80	3.80	4.20	4.00	4.40	4.60	3.80	4.40	2.60	36.6
Japan	4.25	4.75	3.50	4.00	4.75	4.25	4.25	3.50	2.33	35.6
UK	3.00	3.25	3.75	3.00	4.00	3.50	3.00	4.00	2.33	29.8
France	2.33	4.00	4.00	2.33	3.50	3.33	3.00	4.00	3.33	29.8
Taiwan	3.00	5.00	3.00	X	4.00	3.00	4.00	3.00	X	25
China	3.00	4.33	2.67	2.67	5.00	3.67	3.00	4.00	3.67	32.0
Germany	2.67	3.00	2.33	2.67	4.33	2.67	3.67	3.33	3.33	28.0
South Africa	3.00	3.50	3.00	3.00	4.50	2.50	3.00	3.00	2.50	28.0
Australia	2.00	3.00	3.50	4.00	4.00	4.50	3.50	3.00	4.50	32.0

x indicates no information was available

5. CONCLUSIONS

This paper outlined a framework for the identification of best practices in engineering education to promote 21st century engineering leadership. Through the application of this framework to course catalogues, websites, and official plans a number of best practices and trends were identified.

It is evident that institutions all over the globe are taking some steps necessary to bring the engineering curriculum, and thus the profession of engineering, into the 21st century.

It is also evident that Canadian institutions can utilize many best practices from one another and from international institutions. By adapting innovative curriculum content or teaching methods from around the world for the region and accreditation requirements of one's own institution, it is possible to accelerate successful initiatives dramatically. Future research will expand this best practice review to outline opportunities for growth and improvement at nCanadian and international institutions.

- [1] J. Fishbein, "The Global Engineering: An Implementation of Outcomes-Based Accreditation Requirements," *Proceedings of the Canadian Engineering Association*, p. 6, 2011.
- [2] D. G. a. M. B. Burkins, *Holistic Engineering Education*, New York: Springer, 2010.