Employing Multifaceted Teaching and Learning Components to Foster CEAB Graduate Attribute Development

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1) Background: Motivation for Blended Learning

2) Course Format Changes: Multifaceted Blended Learning

3) Resource Allocation: Personnel and Time

4) Targeted CEAB Graduate Attributes and Learning Outcomes

5) Student Performance on Exams, Team Project and GAs

6) Outcomes and Next Steps
1) The Background Story
1989: The Engineering Safety and Risk Management Program was established at the University of Alberta.

- Offered a full multi-disciplinary engineering safety and risk management (ESRM) course to undergraduate students

- Unique to Canada
2015: The David and Joan Lynch School of Engineering Safety and Risk Management was formed at the U of A

- Two courses: ENGG404 Leadership in Risk Management and ENGG406 Methodologies in Engineering Safety
- ENGG404 has evolved to become a benchmark and mandatory course for all undergraduate engineering curriculums
- Created graduate level version of ENGG404
- The School remains unique in Canada and much of North America for delivering ESRM education to engineers.
ENGG404 “Leadership in Risk Management”:

Objective:

➢ To develop core competencies and proficiencies in the leadership principles and practices towards organizational effectiveness for successful risk management.
ENGG406 “Methodologies in Engineering Safety”

Objective:

➢ To develop core competencies and proficiencies in the risk review methodologies and tools as widely practiced in industry.

ENGG406 is a technical elective. Although it was NOT ear-marked to implement multifaceted teaching and learning, improvements made in ENGG404 were tested in or leveraged to ENGG406 in order to accelerate effective implementation.
ENGG404 Perspective:

A Look Back - Prior to 2015:
- Mandatory for Senior Mining and Petroleum Engineers
- Elective for all others
- Total Enrollment hovered around 150 students
- One term per year
- Numerous guest speakers on campus once per year
- Traditional didactic lectures and seminars
ENGG404 Expansion and Challenge:

Expansion - 2016 and After:

- Became mandatory for all engineering students
- Significant enrollment increase:
  - 1100 students per academic year (3 terms)
- Phase-in with ramp-up over ~3 years
- Change in student demographic:
  - Senior level only to a mix of some 2nd year to 5th year
  - co-op and traditional, all engineering fields

Challenge: How do we maintain, even strive to improve the content and delivery of ENGG404? Answer …
2) Course Format Changes:

**Summer 2016**

ENGG 404: Multifaceted Blended Learning Development

**Fall 2016**

ENGG404 Implementation

*Assisted by the Center for Teaching and Learning at the University of Alberta*
Blended learning: “[T]he organic integration of thoughtfully selected and complementary face-to-face and online approaches and technologies”


- Enhanced learning environment through complementary, connected, face-to-face instructional strategies and online approaches
- May include a reduction in the face-to-face contact time
- We took a different approach – turn “sit and listen” time into a scaffolded (or supported) working time with access to members of the instructional team

What is Blended Learning?
In general:

- Improved engagement and student learning experience [1]

- Allows for more guided practice of skills normally practiced individually outside of class time [2]

- For universities, it can compensate for limited classroom space and resources despite increasing enrollment
Specifically for ENGG404:

- Started as logistics solution:
  - manage guest speakers for multiple classes of the course, with increasing frequency of the course.

- Evolved to delivering content to support and “guide learning” in the team project seminars

- Evolved to solidify the requirements for course mapping:
  - Canadian Engineering Accreditation Board Graduate Attributes
  - Course-, Chapter-, and Module-level Learning Outcomes

Why use Blended Learning?
ENGG404 Challenge:

- Sustain the model of a team project, a case study into a real and major industrial loss incident, as a significant part of the course.
- Tailor the course to meet the needs of all engineering fields of study and the levels / years.
- Integrate Blended Learning Techniques and Active Learning Exercises into the course content and delivery
- Evolve to use the available on-line resources for delivering content and assessing students
ENGG404 Course Time:
- 3 hours lecture / week + 1.5 hour seminar / week

ENGG404 Delivery:
- Traditional didactic lectures and seminars
- Multifaceted blended learning format
**ENGG404 Course Time:**
- 3 hours lecture / week + 1.5 hour seminar / week

**ENGG404 Delivery:**

Multifaceted blended learning format:
- Traditional lectures
- Online readings, videos, and quizzes
- Guided in-lecture peer-to-peer discussions
- Guest speakers
- Case studies
- Instructional seminars
- Working seminars with instruction team support

**BL Improvements**

Multifaceted Blended Learning
Module 10-05: Piper Alpha Rig Disaster, North Sea, UK

Video: Piper Alpha DVD, by BBC
Students view on eClass the five segments of the full-length (54 minutes) video, condensed to 8:44 mins:
01:44 – 02:05 Piper Alpha Capacity
06:02 – 10:10 Spiral to Disaster, the incident begins (in class)
13:15 – 14:58 "Don’t Shut Down" (in class)
18:00 – 19:10 “Can we shut down now?”
20:25 – 21:20 “Ask him (if we can shutdown)!”

Access eClass to view these brief snippets in class:
02:25 – 02:55
03:35 – 03:45
05:20 – 06:25

Module 10-05: Piper Alpha Rig Disaster, North Sea, UK

Video: Case Study of this Loss Incident:

BL Example from ENGG404: Piper-Alpha Loss Incident

Module 10-05: Piper Alpha Rig Disaster, North Sea, UK

Failure to secure the commitment of management...
Selected one or two questions, and take two minutes to consider:

> What were the values and priorities?
> How were these translated into the day-to-day activities of workers? What rules were routinely broken?
> How were these translated into the responsive actions ("Do I shut down or not?") by the Rig Manager?

In what other areas was management of risks less than ideal? Hint: Think in terms of the Risk Management System Elements.

What role did Management have in these roles?
Exam Question for the Case Study of a Loss Incident: Piper-Alpha, North Sea, UK

Module 1-06: The Engineer's Survival Guide and Module 10-05: The Piper Alpha Loss Incident

Recall the Piper Alpha Case Study, where an initial gas release escalated to the catastrophic failure of the asset. Choose any one of the Four Key Points of the Engineer's Survival Guide and explain how you would have applied this point in the ongoing operations of Piper Alpha prior to the occurrence of the catastrophic incident. Phrase your responses to answer:

a) What was the situation? (2 marks)
b) What was the issue or concern with that situation? (3 marks)
c) What Key Point was met or was violated? State the Key Point. (1 mark)
d) What would you have done in that situation? (3 marks)
e) What would have been the probable outcome had you done it? (2 marks)

a) What was the situation?

b) What was the issue or concern with that situation?

c) What Key Point was met or was violated?
Previous Seminar Format

- Loss Incident Report
- Guest Speakers
- Seminar Instructions
- Lecture Content
- Unstructured Working Time
New Seminar Format

Teams have the option to work in a provided space
Instruction Team is present to answer questions and provide guidance

Previously Covered Course Content
Lecture material
Individual online learning

Provide instructions on a section of the team project
Demonstrate an example of the work to be completed

Start of term
Time Allocation in Seminars

Loss Incident Report

20
3) Resource Allocation
<table>
<thead>
<tr>
<th>Year</th>
<th>Metric</th>
<th>Total Lecture Time</th>
<th>Blended Learning</th>
<th>For Each Lecture Section (3 total)</th>
<th>For Each Seminar Section (3 total, various sizes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>On-line Assigned Study Time</td>
<td>Guided Peer-to-Peer Discussion Sessions (est.)</td>
</tr>
<tr>
<td>2015</td>
<td>Time</td>
<td>41 hrs</td>
<td>0 hrs</td>
<td>3.5-4.5 hrs</td>
<td>16.25 hrs</td>
</tr>
<tr>
<td></td>
<td>People</td>
<td>1 prof.</td>
<td>None</td>
<td>1 prof.</td>
<td>1 prof.</td>
</tr>
<tr>
<td>2016</td>
<td>Time</td>
<td>41 hrs</td>
<td>2.5 hrs</td>
<td>7-9.5 hrs</td>
<td>16.25 hrs</td>
</tr>
<tr>
<td></td>
<td>People</td>
<td>1 prof.</td>
<td>None</td>
<td>1 prof.</td>
<td>*1 prof. 1-2 TA’s</td>
</tr>
</tbody>
</table>

*1, 2 or 3 instruction team members available per seminar depending on seminar size; 1 member per 10 to 15 teams.
1 Section / Semester
- Lecture: 1 Professor
- Seminar: 1 Professor, 1 TA
- Grading: 1 TA

3-4 Sections / Semester
- Lectures: 3 Professors
- Seminars: 3 Professors, 3 TAs
- Grading: 2 TAs

ENGG404 and ENGG406
Lead Instructor & Instruction Team
- Teaching: Instructors, TAs
- Grading: Grading TAs, TAs, RAs
- Project TAs

Other Courses/Initiatives
- Consulting SMEs
- Professor
- TA / RA
4) Targeted CEAB Graduate Attributes and Learning Outcomes
<table>
<thead>
<tr>
<th>CEAB GA</th>
<th>CEAB Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professionalism</td>
<td>An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.</td>
</tr>
<tr>
<td>Ethics and equity</td>
<td>An ability to apply professional ethics, accountability, and equity.</td>
</tr>
<tr>
<td>Life-long learning</td>
<td>An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.</td>
</tr>
<tr>
<td>Individual and team work</td>
<td>An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.</td>
</tr>
</tbody>
</table>
CEAB Graduate Attributes:

- Professionalism
- Ethics and Equity
- Life-long Learning
- Individual Work, Team Work, and Team Leadership

Learning Outcomes:

- 10 Course-level
- ~30 Chapter-level
- ~250 Module-level
ENGG404 Course Level Learning Outcomes:

- Safety Culture
- Safety Leadership
- Risk Assessment Tools
- Incident Investigation, Root Cause Analysis, and Manage Actions Work Process
- Individual Work, Team Work, and Team Leadership
- Professionalism
- Ethics and Equity
5) Student Performance
<table>
<thead>
<tr>
<th>Assessment</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment 1 Grade</td>
<td>73.1 ± 15.4</td>
<td>71.0 ± 16.1</td>
</tr>
<tr>
<td>Assignment 2 Grade</td>
<td>72.8 ± 19.3</td>
<td>74.1 ± 13.9</td>
</tr>
<tr>
<td>Midterm Exam Grade</td>
<td>76.6 ± 13.0</td>
<td>74.9 ± 9.3</td>
</tr>
<tr>
<td>Final Exam Grade</td>
<td>62.1 ± 9.8</td>
<td>69.0 ± 8.4</td>
</tr>
<tr>
<td>Team Project Technical Report</td>
<td>83.0 ± 9.2</td>
<td>80.7 ± 5.1</td>
</tr>
</tbody>
</table>
Student Performance on Specific GA Exam Questions

Performance on Questions on GA Related Topics (each topic assigned a letter)

- Ethics and Equity
- Life-long Learning
- Professionalism

2016 Final Average Score
2015 Final Average Score

UNIVERSITY OF ALBERTA
Student Performance on Specific GA Exam Questions
## Comprehensive Assessment of Team Member Effectiveness (CATME)

- Online tool, 5 categories, self- and peer-assessment

### CATME [4 – 6]

<table>
<thead>
<tr>
<th>Category</th>
<th>Contributing to the Teams' Work</th>
<th>Interacting with Teammates</th>
<th>Keeping the Team on Track</th>
<th>Expecting Quality</th>
<th>Having Relevant Knowledge, Skills, and Abilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATME Score Average ± St. Dev. (Out of 5)</td>
<td>4.2 ± 0.75</td>
<td>4.28 ± 0.62</td>
<td>4.12 ± 0.80</td>
<td>4.22 ± 0.66</td>
<td>4.32 ± 0.64</td>
</tr>
<tr>
<td>% of Students Scoring &gt; Minimum Performance of a Successful Team Member (3/5)</td>
<td>94.9%</td>
<td>96.6%</td>
<td>90.7%</td>
<td>96.2%</td>
<td>95.8%</td>
</tr>
</tbody>
</table>

**Student Performance – Ind. & Team Work**
6) Outcomes and Next Steps
ENG404 Improvement Outcomes:

Blended Learning improves student competencies while:
- Improving the quality of the course delivery
- Improving the quality of the student experience
- Accommodating significantly increased enrollment

The blended learning project:
- Improved our means to measure student competencies
- Requires in-advance development of course material
ENGG404 Improvement Outcomes:

Solidified and linked learning outcomes with
- CEAB Graduate Attributes,
- Content in course-ware and lectures,
- Assessment methods and marking rubrics for all term work.
ENGG404 Improvement Opportunities:

- Create a series of on-line “mini-documentaries”:
  - Demonstrate industry principles and practices, aligned to learning outcomes

- Create a series of on-line “virtual tours”
  - multiple versions relevant to different fields of study
  - Interactive: viewer “moves through” an area to select different items for more information

- Integrate more “In-class Peer-to-Peer” discussions
ENGG404 Outreach Opportunities:

- Publish a text-book: “Leadership in Risk Management”

- ENGG404 Blended Learning Version:
  - Transportable, Adaptable

- Transfer Learning to Other Learning-Institutions.
  - Create a “Turn-key” Course complete with Instructor’s Manual (lecture presentations, assessment methods)
ESRM Growth and Outreach Opportunities:

- One or more under-graduate courses with specialized risk management topics e.g. geotechnical, environmental assessment

- One or more graduate-level courses, and permanent offering of ENGG404 Graduate-level version

- Expand Learning to Industry:
  - Seminar and certificate-level courses

Next Steps
The authors acknowledge the efforts of Dr. Norman Nibber, Mr. Nicholas Bak, and Mr. Pradyumna Kedarisetti as members of the instruction team delivering ENGG404, and the Centre for Teaching and Learning for their assistance with conversion of course content and expertise in blended learning. The authors also acknowledge the financial support of the Centre of Teaching and Learning.

References


Thank You!

Questions?
How:

- Integrated seminars: combined instruction and guided learning opportunities for the team project.
- Teams formed on basis of program/plan/year: loss incident is specific, work with peers.
- Active Learning Exercises “Please confer!” in lectures.
- On-line videos or assigned reading c/w quizzes.
- On-line submission and marking of all term work.
- On-line administration of mid-term and final exams.
- Growth of the ESRM Instruction Team – depth and breadth in the fields of study.
Piper-Alpha, North Sea, UK

Learning Outcomes for this Module, a Case Study:

The student should be able to:

- Summarize the cause & effect of this event, how an event can escalate, and the underlying value of investigating and analyzing loss incidents.
- Describe the benefits of a Safety and Risk Management Program.
- Critique of management leadership (or lack thereof) in an industrial facility / operation.
- Argue in favour of the need for management leadership, commitment, and accountability at all levels, and the underlying values for what drives those needs.
- Apply the Engineer’s Survival Guide
On-line Quiz:
Chemical Release; UCIL Pesticide Plant; Bhopal, India.

BL Example from ENGG404: Piper-Alpha Loss Incident
In-class “Peer-to-Peer” Active Learning Exercise: Piper-Alpha, North Sea, UK

Module 10-05: Piper Alpha Rig Disaster, North Sea, UK

“Failure to secure the commitment of management …”
Select one or two questions, and take two minutes to confer:

- What were the values and priorities?
- How were these translated into the every-day activities of workers? What rules were routinely broken?
- How were these translated into the responsive actions (“Do I shut down or not?”) by the Rig Manager?
- In what other activities was management of risks less than ideal? Hint: Think in terms of the Risk Management System Elements.
- What if Rig Management had audited and enforced these rules?

BL Example from ENGG404: Piper-Alpha Loss Incident