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Competency-Based Assessment in First Year Engineering at USask

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Land Acknowledgement

In the spirit of reconciliation, we recognize and acknowledge that the land on which we live and work is unceded Treaty 6 territory, the traditional lands of the Cree, Saulteaux, Stony, Nakota, Dakota, and Lakota, and the homeland of the Métis.

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Presentation Overview

- Setting the Stage
- The USask CBA Implementation
- How has it Gone?
- Current/Future Work

Setting the Stage

What if you could scrap your current program and start over … with no restrictions?

How would you construct your program?

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Attract more diverse students

Assist in making better career decisions

Promote and develop LLL**

Integrate learning across courses

Develop professional ethics

Sequence learning progressively

Prepare for future with KSEA***

Respect and value DEI*

Assess more accurately, supporting improvement

Encourage holistic health/balance

*DEI – Diversity, Equity, Inclusion
*LLL – Life Long Learning

***KSEA – Knowledge, Skills, Experiences, Attitudes

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New Program from 2021/22

	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	18	19	20	21	22	23	24	26	27	28	29	30	31	32	33	34
Apr-Aug	Sept				Oct				Nov				Dec			Jan				Feb				Mar					Apr		
Summer Top Ups (Online)	GE 102.2 Intro to Profession	Natural Science Series: PHYS 152.1, CHEM 142.1, GEOL 102.1, BIOL 102.1												GE 102.2 Cont'd	GE 112.1 Engineering Discipline Experience	PHYS 156.3 Electromagnetism and Waves for Engineering								GE 153.2 Electrical Circuits II					GE 143.2 Design II		
		MATH 133.4 Engineering Math I														CHEM 146.3 General Chemistry for Engineering								GE 163.2 Process Engineering							
		CMPT 142.3 Intro. to Computer Science for Engineers							GE 132.1 Engineering Communication I							GE 133.2 Engineering Communication II												GE 103.1 Cont'd				
									GE 152.1 Circuits I & Matlab																						Discipline Bridge Course: CMPT 146.3 / ME 113.3 / CHE 113.3 / CE 271.2
									GE 142.2 Design I							GE 103.1 Intro to Engineering II								GE 123.3 Engineering Mechanics II								
		GE 102.2 Indigenization							GE 122.2 Engineering Mechanics I															MATH 134.3 Engineering Math II							
									Fall Top Ups															Winter Top Ups							

Students Select Top 3 Discipline Choices

Final Discipline Assignment

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New Program Weekly Schedule

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
8:30 AM	Lecture or Lab	Lecture or Lab	Lecture or Lab	Lecture or Lab	Lecture or Lab
9:00 AM					
9:30 AM					
10:00 AM	Lecture or Lab	Lecture or Lab	Lecture or Lab	Lecture or Lab	Lecture or Lab
10:30 AM					
11:00 AM					
11:30 AM	Lunch/Rec	Lunch/Rec	Lunch/Rec	Lunch/Rec	Lunch/Rec
12:00 PM					
12:30 PM	Lecture or Lab		Lecture or Lab		Lecture or Lab
1:00 PM		Lecture or Lab		Lecture or Lab	
1:30 PM					
2:00 PM	Lecture or Lab		Lecture or Lab		Lecture or Lab
2:30 PM		Lecture or Lab		Lecture or Lab	
3:00 PM					
3:30 PM	Tutorial (Optional)		Tutorial (Optional)		Tutorial (Optional)
4:00 PM		Tutorial (Optional)		Tutorial (Optional)	
4:30 PM					

Why Competency Based Assessment (CBA)?

- **What do conventional grades really mean?**

  What is a 78 versus a 79? If they get a 60, what do they know? With a mix of questions of different difficulty levels, do you know what they can/can't do at term's end?

- **Do such grades clearly measure success against targeted learning outcomes?**

  If a student passes, do you know if they have the skills and knowledge that you want? Can you identify those learning outcomes with confidence?

- **What are students focused on in traditional assessment?**

  Passing tests, acing assignments, completing labs … are they focused on learning specific outcomes?

- **Can students learn at their own pace or must they learn at yours?**

  If they get something wrong, early on, can they redeem themselves? Can they learn formatively at any point or is it all summative? What if they are sick or absent for a test?

What is CBA?

- found in programs like Medicine … but not in Engineering
- some key principles of CBA:
  1. focus on Learning Outcomes (LOs) in a Constructive Alignment (CA) framework – rubrics, and students, focus more on LOs
  2. give multiple chances to exhibit competency – typically later weighted heavier
  3. focus on where students get to, not how they get there – can fail at first
  4. give students agency in how to exhibit competency – employ learning strategies
  5. set clear and transparent performance expectations – know what's assessed & how
  6. to pass a course, students must achieve all competencies – set thresholds
  7. students can complete the work on their own timeline – work at own pace

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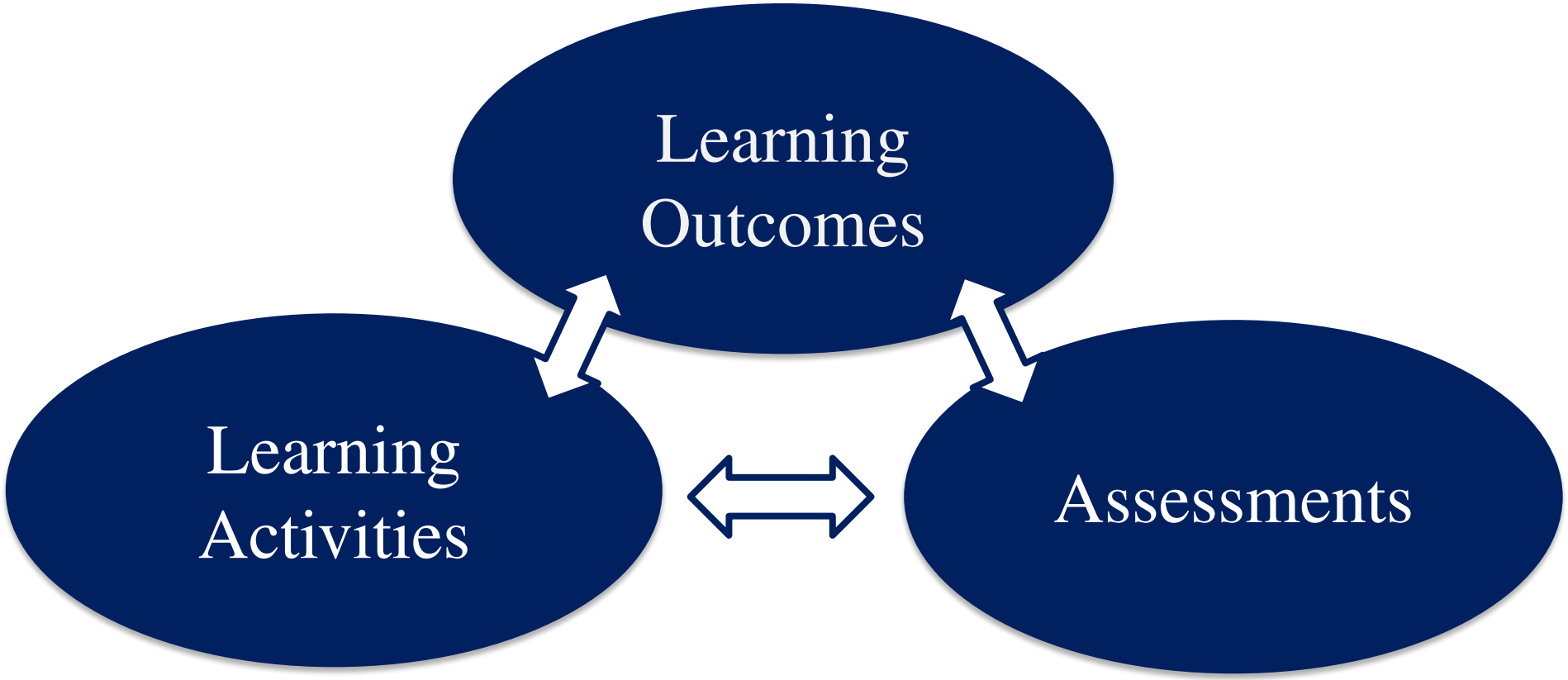
Constructive Alignment (CA)



Biggs. J. (2003) Teaching for Quality Learning at University – What the Student Does 2nd Edition SRHE / Open University Press, Buckingham.

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A Side-by-Side Comparison
Traditional vs. Competency Based Assessment

Traditional Exam

- everything covered in the term is fair game
- students don't know difficulty level of questions or topics that *will* be on exam (just those that *could be*)
- students assume grading rubric will be similar to previous assignments
- each question will contribute proportionally or equally to final grade
- weight of exam is known beforehand
- typically high anxiety/pressure

CBA Module Test

- most (or all) LOs in the module are tested
- students know the types of questions that will be asked, and their difficulty level
- grading rubrics are same as for assignments, and can be reviewed beforehand
- each LO evaluation is worth a lot if they do well, typically less if they do poorly
- high anxiety/pressure if not passing yet, otherwise can be lower pressure

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A Side-by-Side Comparison
Traditional vs. Competency Based Assessment

Traditional Exam

- difficulty level of each question is not made clear; but grade level that must be achieved over the whole exam is known beforehand
- questions are graded such that all aspects of a question contribute to the final score for a question
- get scores for each question and for whole test

CBA Module Test

- difficulty level of each question is shown, indicating the level of competency that must be exhibited for each question
- questions are graded such that each LO is graded separately (typically one to two independent LOs per question)
- get scores for each LO covered in test (total scores have no explicit meaning)

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A Side-by-Side Comparison
Traditional vs. Competency Based Assessment

Traditional Exam

- don't know if students have competencies on question types that weren't asked
- students survive on part marks i.e. mediocre scores indicate little about competencies on question types that were asked
- students fail questions (even the Exam) and still pass, making clear they lack competencies
- instructors have a broad (& possibly misleading) sense of student competency at the end of the course

CBA Module Test

- typically all LOs are covered for a module i.e. no stone is left unturned
- in combination with previous assessments of LOs, instructors know how a student did on specific skills throughout module
- students must demonstrate minimum levels of competency in all (or most) LOs to pass
- instructors have a much clearer picture of what their class (and each student) can/can't do at the end of the module

The USask CBA Implementation

- what should/could CBA look like in Engineering?
- there is no broadly accepted “best way” to implement CBA; everyone does it differently
- this is one of the challenges around adoption
- what follows is how we do it at USask in Engineering
- best to regard it as an example of how one could implement CBA
- I will note key parameters as we go (these are fairly universal)

The USask CBA Implementation

1. Focus on LOs in a CA framework

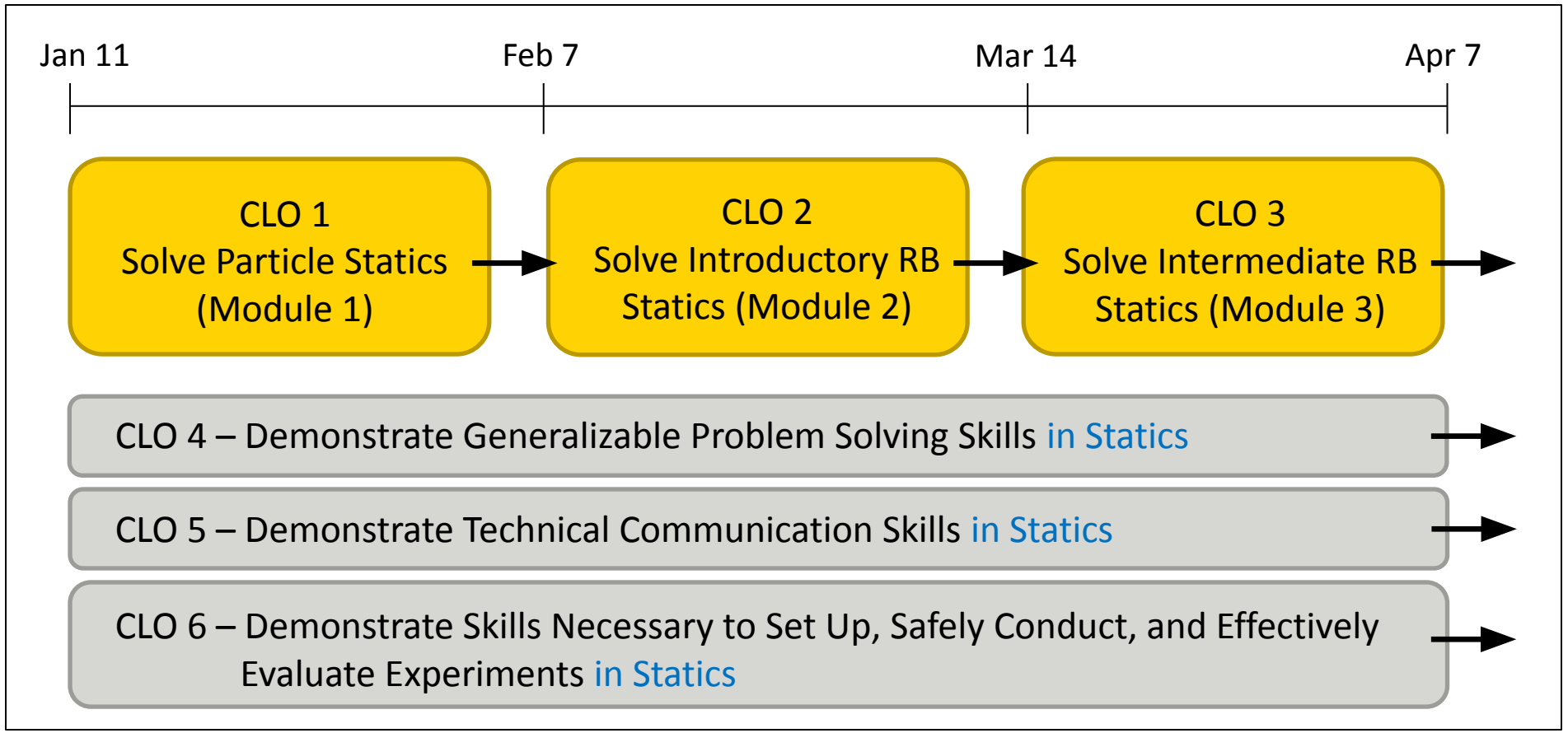
- different levels:
  - program LOs (PLOs), course LOs (CLOs), root LOs (RLOs), sub-LOs (SLOs)
  - aligns pretty well with Greenfield Learning Object Model (Falkenburg, 2005)
- evaluate LOs specifically
  - corollary: LOs have grade "weight", not assignments/labs/tests
- grades depend on performance against LOs; students focus on them
- modules align with CLOs, which are evaluated independently
- an example …

CLO 1 - Solve Particle Statics Problems (25% of Final Course Grade)

CLO 1 will be assessed in a module (Module 1). By the end of this module, students will be expected to:	Weight (%)
RLO 1.1 recognize, define, and use terms relevant to 2D and 3D particle equilibrium, and perform simple calculations relevant to 2D and 3D particle equilibrium; (Type A)	Pass/Fail
RLO 1.2 add and subtract vectors using the parallelogram, triangle and Cartesian methods in order to solve basic vector problems (Type B/C);	20
RLO 1.3 utilize dot products of 2D and 3D vectors to solve problems (Type B/C);	15
RLO 1.4 apply the equations of equilibrium to calculate unknown forces in 2D particle equilibrium problems (Type B/C);	30
RLO 1.5 apply the equations of equilibrium to calculate unknown forces in 3D particle equilibrium problems (Type B/C).	35

CLO 4 - Demonstrate Generalizable Problem Solving Skills in Statics (7% of Final Course Grade)

CLO 4 will be assessed throughout the course. By the end of this course, students will be expected to:	Weight (%)
RLO 4.1 frame solutions to 2D and 3D statics problems with Given, Find, Assumptions, diagrams/FBDs, equations of equilibrium from the FBDs, and Conclusions; (Type A)	Pass/Fail
RLO 4.2 exhibit technical accuracy and thoroughness in framing solutions to 2D and 3D statics problems with Given, Find, Assumptions, diagrams/FBDs, equations of equilibrium from FBDs, and Conclusions (Type B); and	50
RLO 4.3 identify and classify statics problem types and features (Type B/C).	50


Jan 11
Feb 7
Mar 14
Apr 7
CLO 1
Solve Particle Statics
(Module 1)
CLO 2
Solve Introductory RB
Statics (Module 2)
CLO 3
Solve Intermediate RB
Statics (Module 3)
CLO 4 – Demonstrate Generalizable Problem Solving Skills in Statics
CLO 5 – Demonstrate Technical Communication Skills in Statics
CLO 6 – Demonstrate Skills Necessary to Set Up, Safely Conduct, and Effectively Evaluate Experiments in Statics

The USask CBA Implementation

2. Give multiple chances to exhibit competency

- every RLO is typically assessed at least 3 times
- sequential modules each end in "Module Tests" (MTs)
  - no cumulative final exams
- Top Up Module Tests offer further chances to exhibit competency, if needed

The USask CBA Implementation

3. Focus on where students get to, not how they get there

- say RLO 1.2 is assessed three times (two assignments, one MT)
- first assignment: RLO 1.2 is graded, yielding a percentage grade indicating a level of "developing competence"
- second assignment: if new grade for this RLO is better than first grade for this RLO, keep new grade (otherwise average them)
- Module Test: if new grade for this RLO is better than current grade for this LO, keep new grade (otherwise average them)
- later assessments have more weight → one can stumble and recover

The USask CBA Implementation

4. Give students agency in how to exhibit competency

- say Student #1 does well on all of the assessments for RLO 1.2
- say Student #2 has trouble with RLO 1.2 in the assignments, but excels later in the Module Test (MT) or even the Top Up
- say Student #3 skips all the assignments and just does the MT, and excels at RLO 1.2
- we view the outcome as the same in all 3 cases i.e. competency
- traditional assessment says all students must be Student #1 to do well

The USask CBA Implementation

5. Set clear and transparent performance expectations

- on assignments, students know ahead of time which RLOs will be assessed (though not always on which questions)
- for Module Tests, students know ahead of time which RLOs will be assessed (and usually on which questions, except for PLOs)
- rubrics for all RLOs are available to students at all times
- reactions from students and faculty to this are typically "strong" … it is a litmus test of one's belief in Constructive Alignment
- students can focus their preparations

Different Standards for Different Levels of Knowledge/Skills

Type A – fundamental definitions/skills that need to be automatized

- pass/fail, unlimited tries, automated evaluation

Type B – basic fully integrated problems, characteristic of the field

- need at least 70% to pass module, multiple tries (3+), marked by TAs

Type B+ – typically writing/design assignments (span B/C range)

- need at least 50% to pass module, multiple tries (2+), marked by TAs/instructors

Type C – “difficult” fully integrated problems; tough/tricky problems

- no minimum grade required, single chances, marked by instructors

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e.g. apply the equations of equilibrium to calculate unknown forces in 2D particle equilibrium problems

Rubrics

Mastery Category	Grade Value	Performance Level (RLO 1.2-1.5)
mastery	**100**	accurate/complete diagram(s), correct/matching equation(s), correct computations, clear solution presentation, no gaps in process logic i.e. no errors and nothing is missing
developing mastery	**90**	mastery with 1-2 small errors i.e. minor computation mistake, small error in clarity, minor gap in process, or minor error/omission in diagram
competence	**70**	right/complete approach with 3-4 small errors (computational, process logic, clarity, missing/wrong diagram feature or equation term)
developing competence	**50**	right approach but 1 major error i.e. major mismatch/error/omission in equations/diagrams, major computational error, process logic wrong/missing/unclear, or equation terms missing, and/or missing as much as 50% of the solution
not yet competent	**30**	an incomplete (i.e. <50%) attempt to solve and/or wrong approach (or we can't understand it) including 2+ large errors (computational, missing steps, missing/wrong diagram features or equations)
no evidence of competence	**0**	no meaningful submission

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6. To pass a course, students must achieve all competencies

- within a CLO, the average grade for Type B RLO's must be 70%+
- within a CLO, the average grade for Type B+ RLO's must be 50%+
- with these standards, we are still getting up to 35% writing Top Ups
- at some point, we hope to get to a point where every student must meet the thresholds for every RLO

The USask CBA Implementation

7. Students can complete the work on their own timeline

- we have not implemented this principle, largely because our courses handle 500+ students each i.e. the logistics are too challenging

How has it Gone?

Iteration 1: Fall 2020 – GE 124 Mechanics I (Statics)

- 400 FY engineering students, synchronous remote teaching
- weekly live (online) tutorial sessions
- confounding issues:
  - remote teaching (synchronous/live lectures with 2 instructors)
  - open book, remote assessments
  - potential for cheating

How has it Gone?

- failure rate similar to previous years but mostly due to no-shows
- higher grades (+10-15%) but work quality was clearly higher too
- confusion regarding CBA system for many (staff and students)
- fair/flexible due to 3+ chances and clear multi-level expectations
- forgiving for sickness/absence, especially helpful in COVID
- anecdotally, lower stress for students
- cheating likely pretty prevalent

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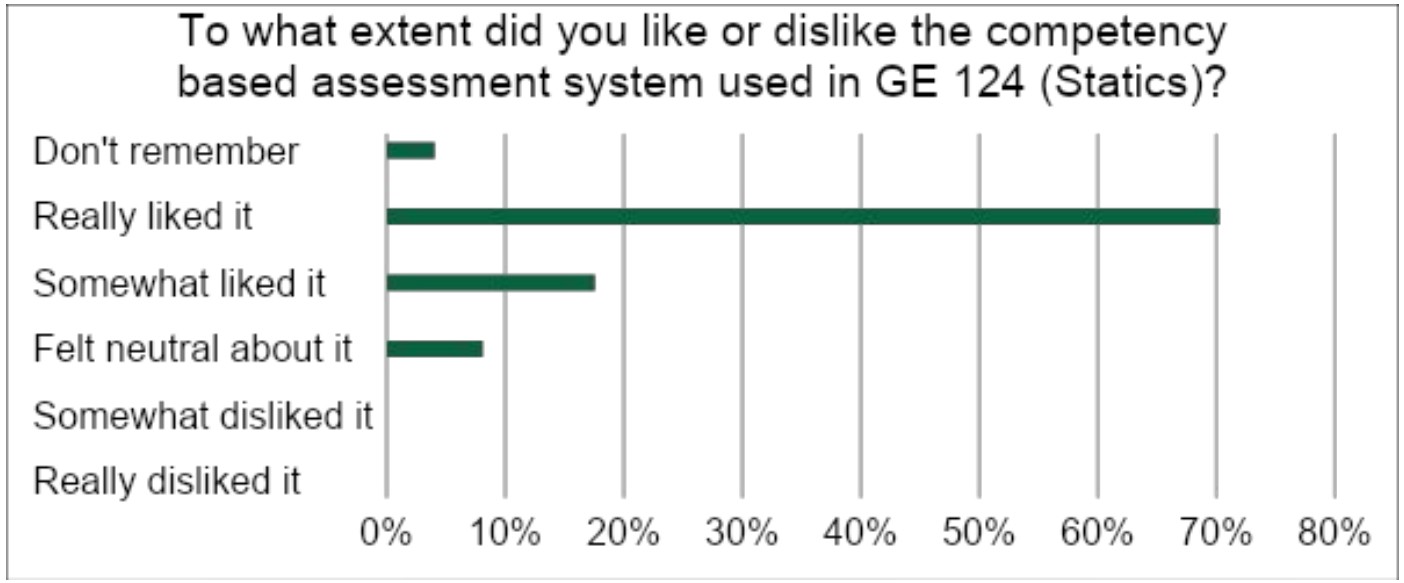

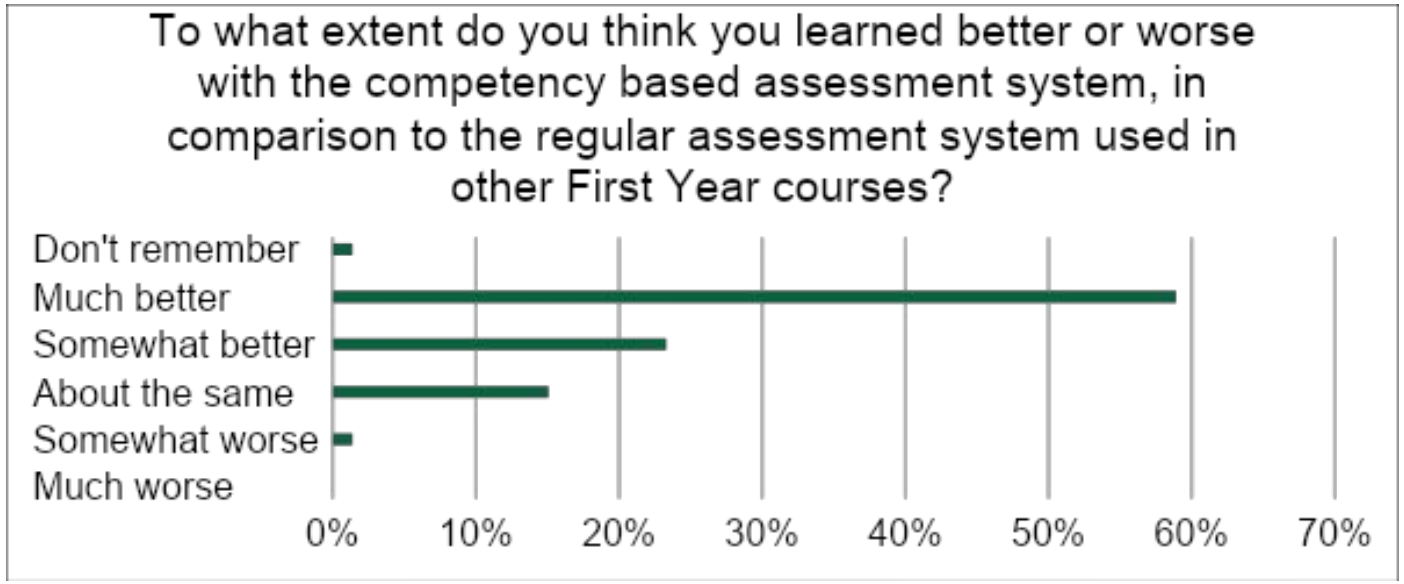

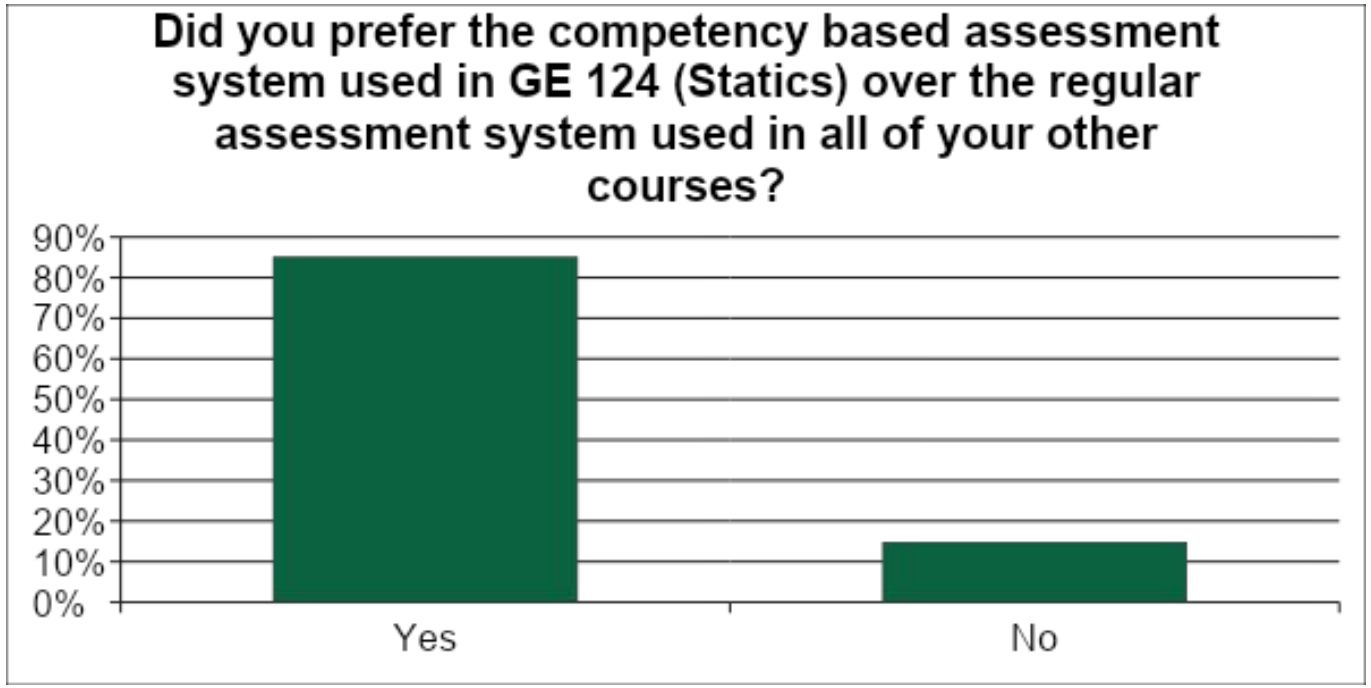
Did you prefer the competency based assessment system used in GE 124 (Statics) over the regular assessment system used in all of your other courses?
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Yes
No

How has it Gone?

Iteration 2: Fall 2021/Winter 2022 – most FY courses

- 400 FY engineering students, remote/in-person mix
- confounding issues:
  - some remote teaching esp. in Fall (synch/asynch lectures)
  - open book, remote assessments
  - cheating likely pretty prevalent

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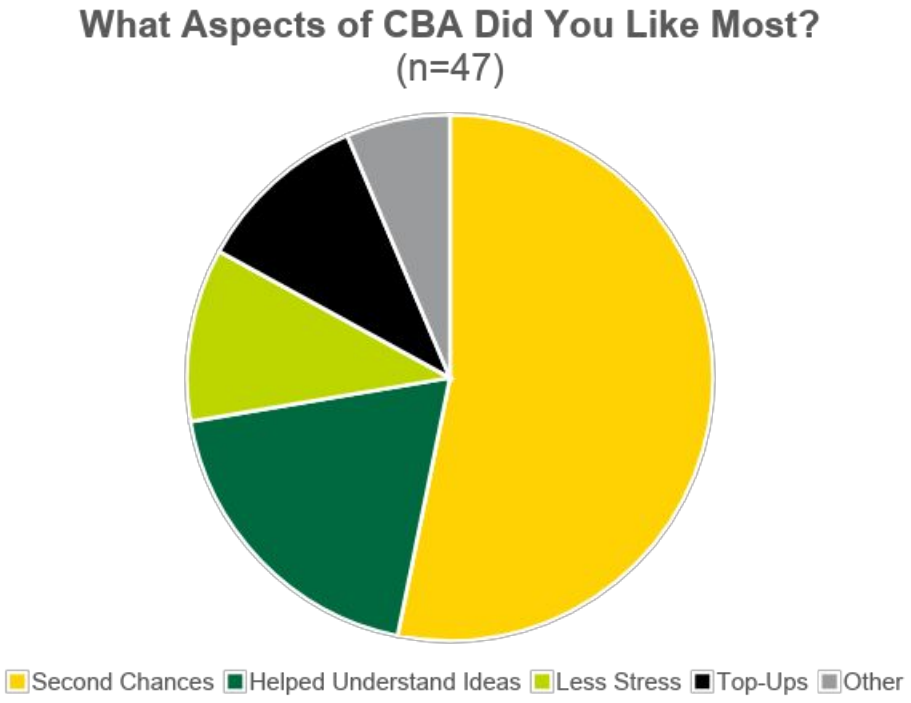
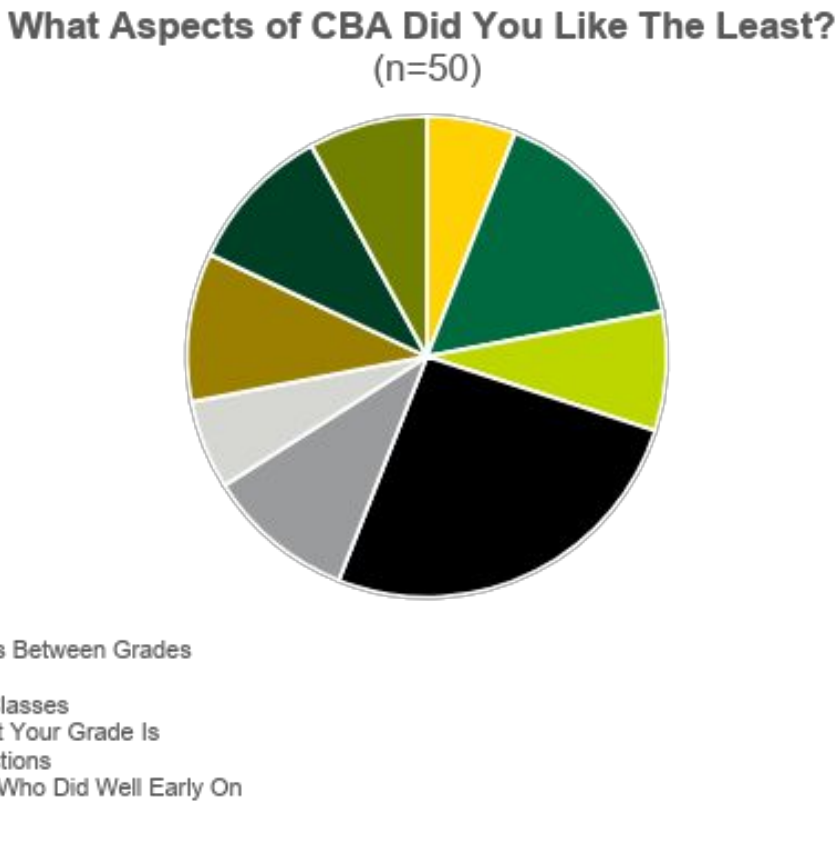
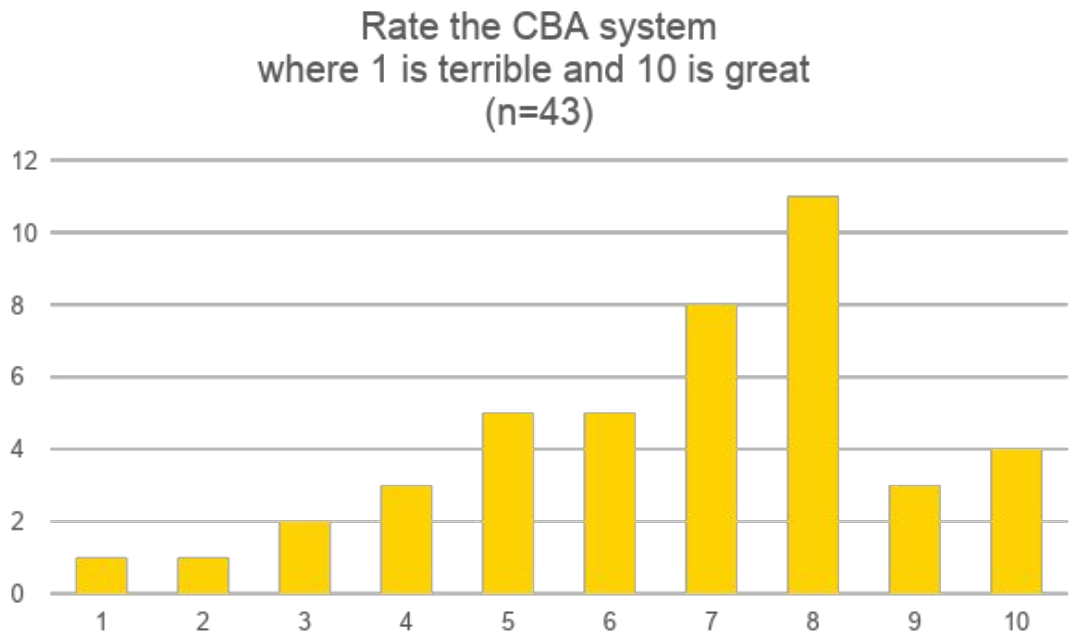
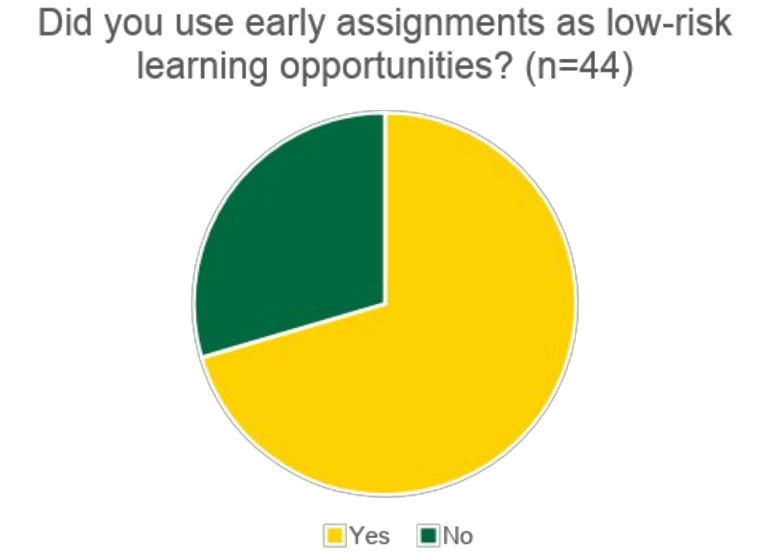
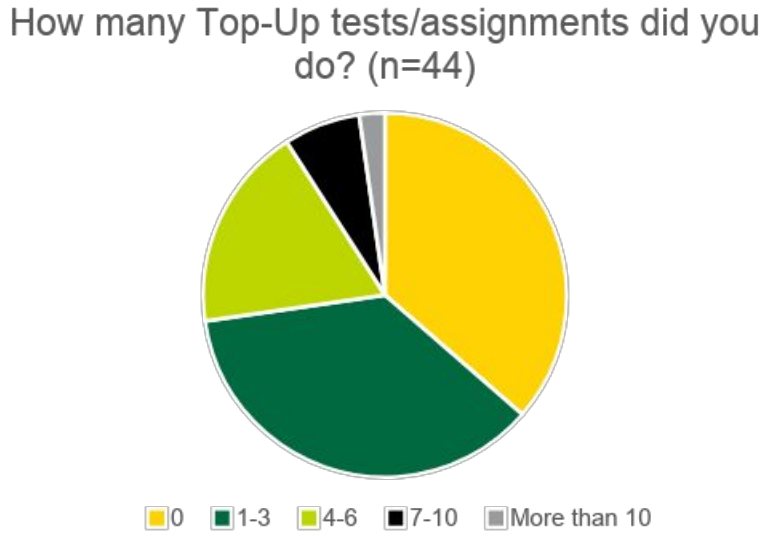
How has it Gone?






Rate the CBA system
where 1 is terrible and 10 is great
(n=43)
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10


Did you use early assignments as low-risk learning opportunities? (n=44)
Yes
No


How many Top-Up tests/assignments did you do? (n=44)
0
1-3
4-6
7-10
More than 10

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How has it Gone?

- **Constructive Alignment is Baked In**
  Set LOs. Assess them. Teach to them. CBA explicitly forces the first two, and encourages the third. It REALLY discourages instructors from trying to pack too much into a course.
- **Assessments are Meaningful**
  Grades (for LOs) mean something specific now i.e. how well can they perform those skills.
- **Graduate Attribute Data is Readily Available and Trusted**
  Your grades are by LO. Graduate attributes can directly relate to the LOs.
- **Students Focus on Skill Development**
  Students pass/fail specific skills. They know what to study and where their strengths/weaknesses are.
- **System Works Well Once Set Up**
  Making tests and assignments is easier than in traditional system.
- **Learners are Respected, Empowered and Given Time to Learn**
  Students move at their own pace. They make decisions about assessments. They can recover from stumbles, sickness, and absence.

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How has it Gone?

- **Can Be Resource Intensive**
  More grading to be done i.e. more assignments/tests. Set up takes time.
- **Can Be Challenging to Schedule**
  Multiple iterations of "perform, get feedback, try again" are challenging in some contexts. Pacing is key.
- **Can Be Too Reductionist**
  Breaking everything into lower-level LOs can neglect higher level integrative skills. Must be careful.
- **Grade Calculations Can be Complicated, including Predicting Final Grades**
  More stuff to keep track of. Complex updates after each assessment. Students and staff can get confused and challenged. Prediction depends on understanding calculations.
- **Can Be Hard to Integrate with LMS**
  Most LMS's aren't made to handle CBA. Kluges are challenging.
- **Devil is in the Details**
  Getting some details wrong can lead to a cascade of problems. If traditional assessment can be thought of as a set of guitar strings, then CBA is like a spider's web i.e. everything is interconnected.

Current/Future Work

- validation: limitations on validity of results so far due to
  - COVID, online courses, admissions, open book testing, cheating, survey sample sizes
- Type A/B/B+/C system and rubrics need fine tuning (normal)
- reduce size of Type A quizzes; must complete to do Type B's
- handling late assignments

Current/Future Work

- poll 2nd year students regarding CBA vs. traditional assessment
- create software to make grade tracking logistics easier
- make marking more efficient; train TAs better on Crowdmark and on applying rubrics
- in-person testing this year; higher failure rates

Final Word

There's no truly free lunch with CBA. You pay for the benefits, but they are likely significant.

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Thank You for Your Attention

Any Questions?

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