



Implementation and assessment of a merged organic and general chemistry four-semester sequence for a health science degree

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Outline

1) A new chemistry curriculum for health sciences

1.A) What problem are we trying to solve?

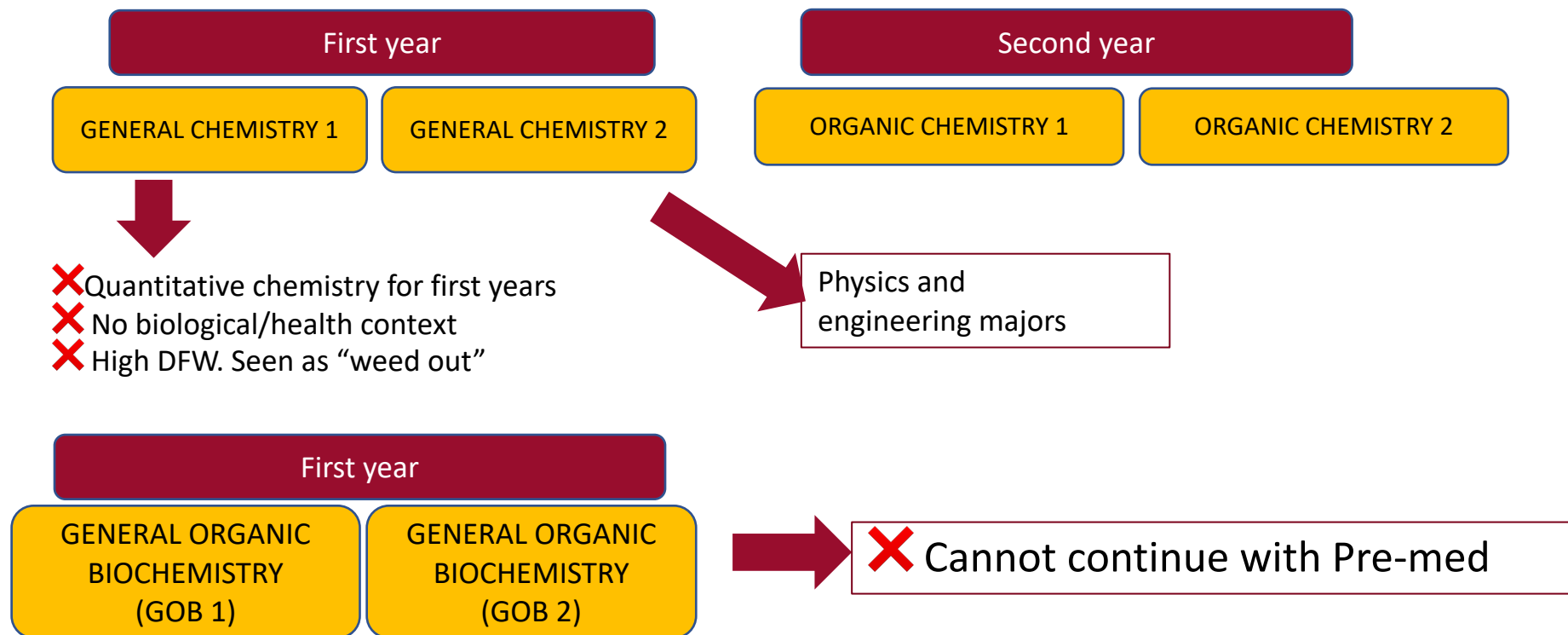
1.B) Design and implementation

2) Innovative Assessment: helping first-years

2.A) What problem were trying to solve?

2.B) **Milestones:**
Design, implementation, and results

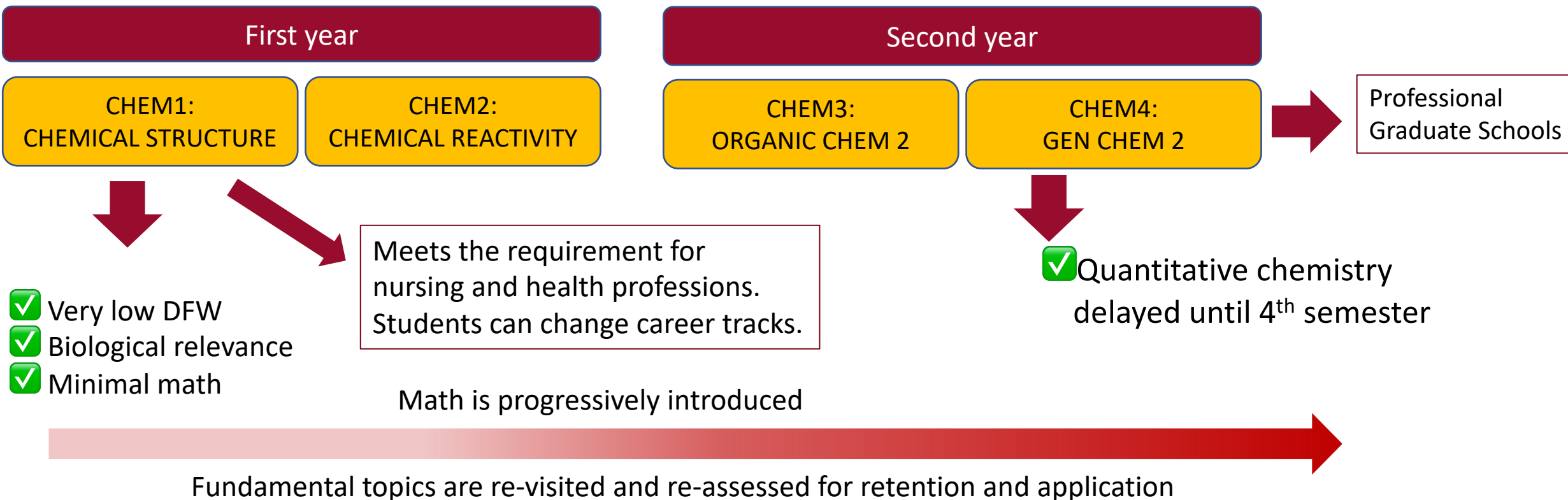
1. A new chemistry curriculum for health sciences: What problem are we trying to solve?



Our Goal:

- ➔ Avoiding tracks in chemistry courses
- ➔ Taking down the artificial barrier between GenChem and OChem
- ➔ Preventing a first-year quantitative chemistry barrier that "weeds out" students

1. A new chemistry curriculum for health sciences: What problem are we trying to solve?



Challenges:

- ➔ No textbook will cover this level of mixture.
- ➔ CHEM1+CHEM2: Transfer as GenChem1 and OChem1 when taken together.
- ➔ You need a team of faculty interested. You need a department willing to change.

1. A new curriculum for health sciences: Design and implementation

General Chemistry 1

SI units
Dimensional analysis
Atoms, Moles and Mass
Stoichiometry Calculations
Ideal Gases
Theory of light and electronic structure
Periodic Table
Chemical bond: Lewis structures
Molecular orbital theory
Intermolecular forces and phase change
Solutions: properties and preparation

General Chemistry 2

Chem. Kinetics: Descriptive concepts
Chem. Kinetics: Integrated rate laws and Arrhenius
Thermodynamics: Descriptive concepts
Thermodynamics: Hess law and quantitative equil.
Quantitative Equilibrium
Electrochemistry
Acid/Base: Reactions, K_a , K_b and approximate pH.
Acid/Base: Titrations, buffers and ICE tables.
Precipitation Equilibria
Metallic Complexes: Bonding and Equilibria

CHEM1	Atoms and Moles	Mass spectrometry
	Theory of light and electronic structure	
	Periodic Table	
	Chemical bond. Lewis structures. Hybridization	
	Functional groups. Overview of conformation.	
	Introduction to IR and NMR spectroscopy	
	Intermolecular forces and phase change	
	Solutions: properties and preparation	
CHEM2	Chem. Kinetics: Descriptive concepts	
	Conformational analysis	
	Thermodynamics: Descriptive concepts	
	Acid/Base: Reactions, K_a , K_b and approximate pH.	
	Stereochemistry	
	Nucleophilic Substitutions	
	Addition to alkenes	
CHEM3	Conjugation and Ultraviolet spectroscopy	
	Aromaticity and Aromatic substitution	
	Alcohols and Ethers	
	Carbonyl Reactivity	
	Carboxylic and acyl derivatives	
CHEM4	Kinetics theory of gases. Ideal gas models.	
	Chem. Kinetics: Integrated rate laws and Arrhenius	
	Quantitative Thermodynamics	
	Stoichiometry and quantitative equilibrium	
	Electrochemistry	
	Acid/Base: Titrations, buffers and ICE tables.	
	Metallic Complexes: Bonding and Equilibria	

Data Visualization

Algebra

Calculus

Organic Chemistry 1

Bonding: Hybrid orbitals.
Resonance.
Acid/Base and polarity
Functional groups. Overview
Alkanes
Conformation of alkyl chains
Cycloalkanes
Alkenes and alkynes: structure
Alkenes and Alkynes reactivity.
Stereochemistry
Nucleophilic substitution.

Organic Chemistry 2

Mass spectrometry
Infrared spectroscopy (IR)
Nuclear magnetic resonance (NMR)
Conjugation and Ultraviolet spectroscopy
Aromaticity and Aromatic substitution
Alcohols and Ethers
Carbonyl reactivity
Carboxylic acid and acyl derivatives
Amines and Heterocycles

GenChem

OChem

Spectroscopy

Atomic theory

Lewis struct

3D Molecular
Structure

Non-covalent
interactions

Phase change

Thermochemistry

Solubility and
solutions



Skeletal structure of
hydrocarbons. isomerism

Hybridization. Polarity and
molecular dipole. Conjugation
and resonance

Functional groups

Non-covalent interactions of functional groups. Heat capacity,
enthalpy of phase change of organic substances

Vapor pressure and solubility of
organic solvents

Biomolecules: structure, polarity,
and chirality

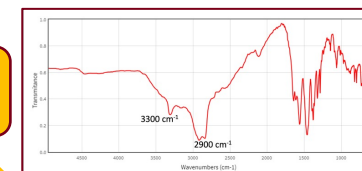
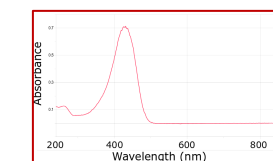
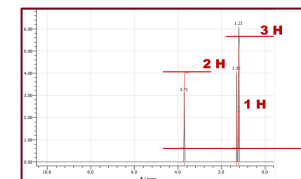
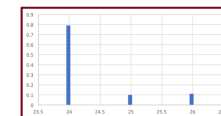
Isotopic Mass
Spectrometry

^1H -NMR and ^{13}C -NMR of
hydrocarbons

UV/Vis spectroscopy

IR of functional groups

Thin layer
chromatography



1. A new curriculum for health sciences: Design and implementation

What to teach: Content

How to design
a new curriculum?

How to teach:
Pedagogies of delivery

Homework
practice

Class activities

How to assess it:
Questions
and Artifacts

Backwards design:
Your learning objectives
must be reflected in
your assessment.

Transparency

Exams

Specs grading
A / C / F scale

Cumulative

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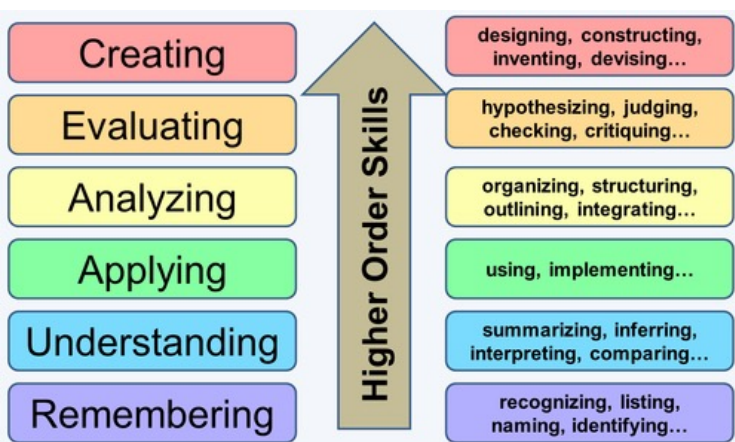
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2. Innovative assessment: Milestones



Exams before 2018

Midterm written exams:

Low-level questions

Mixed with

High-level questions

Since 2018

Milestones Exams

Low level questions. Specs grading.

Scheduled First

Open Ended Exams

High level questions. Partial credit.

Scheduled After

2. Innovative assessment: What problem are we trying to solve?

Problem I: How to college

Some first-year students lack study skills and how to study for exams.
Need help lowering cognitive load.
Some with exam anxiety: a "one shot" exam/opportunity is too high risk.

Problem II:

Lack of retention of fundamental concepts to be applied to next course.

Problem III:

Avoid busy work and align class activities, homework, and exams.
Homework does not help students: does not correlate with course grade

Challenges:

Give the questions ahead of time

Questions are "low-order" skills

Graded on A/C/F

Multiple attempts

Cumulative

Assign the same exercise as homework

Design MANY and MEANINGFUL questions

Scheduling reattempts

2. Innovative assessment: What problem are we trying to solve?

Implementation:

- **Milestones: 30% of the grade**
- **Online quizzes, timed 50 minutes, proctored with LockdownBrowser**
Automatically graded. Immediate feedback. 3 attempts.
- **Graded on A/C/F**
 - **A 100: score > 80%**
 - **C 80: 70% < score < 80%**
 - **F 0: score < 70%**
- **Same Question Bank is due the night before the first attempt**
- **The third attempt is not later than 2 weeks after the first**
Fail quick during the first semester

Give the questions ahead of time

Questions are “low-order” skills

Graded on A/C/F

Multiple attempts

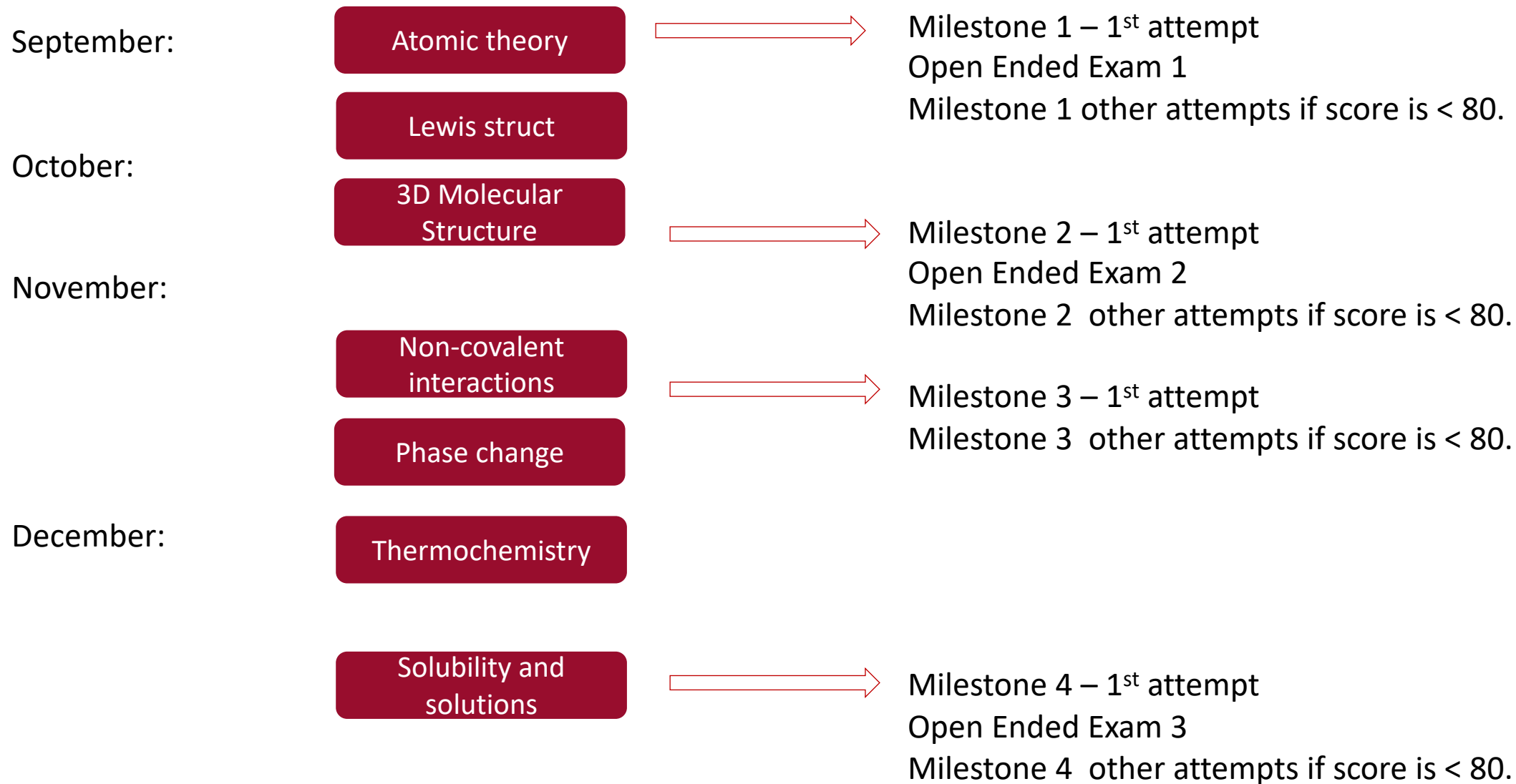
Cumulative

Assign the same exercise as homework

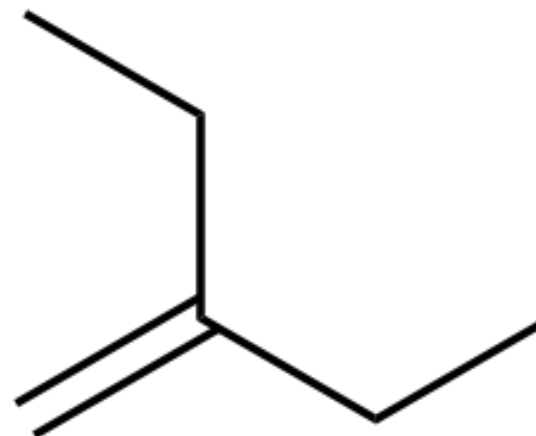
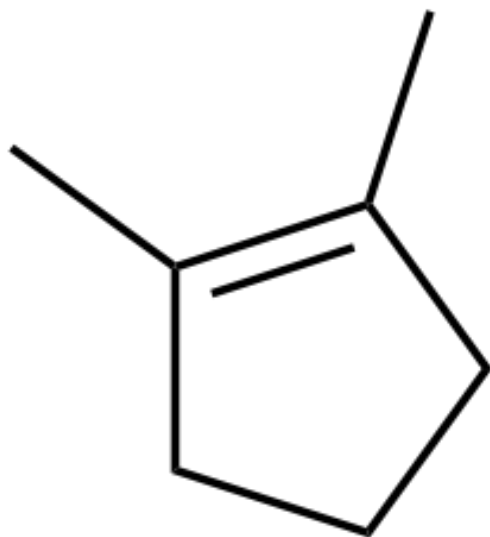
Design MANY and MEANINGFUL questions

Scheduling reattempts

2. Innovative assessment: Milestones – The scheduling



2. Innovative assessment: Milestones – Designing meaningful questions



The compound on the left has:

[response1] hydrogens, [response2] sp³ carbons, and [response3] sp² carbons.

A total of [response4] groups of non-equivalent hydrogens (or number of signals on ¹H-NMR)

A total of [response5] groups of non-equivalent carbons (or number of signals on ¹³C-NMR)

The compound on the right has:

[response6] hydrogens, [response7] sp³ carbons, and [response8] sp² carbons.

A total of [response9] groups of non-equivalent hydrogens (or number of signals on ¹H-NMR)

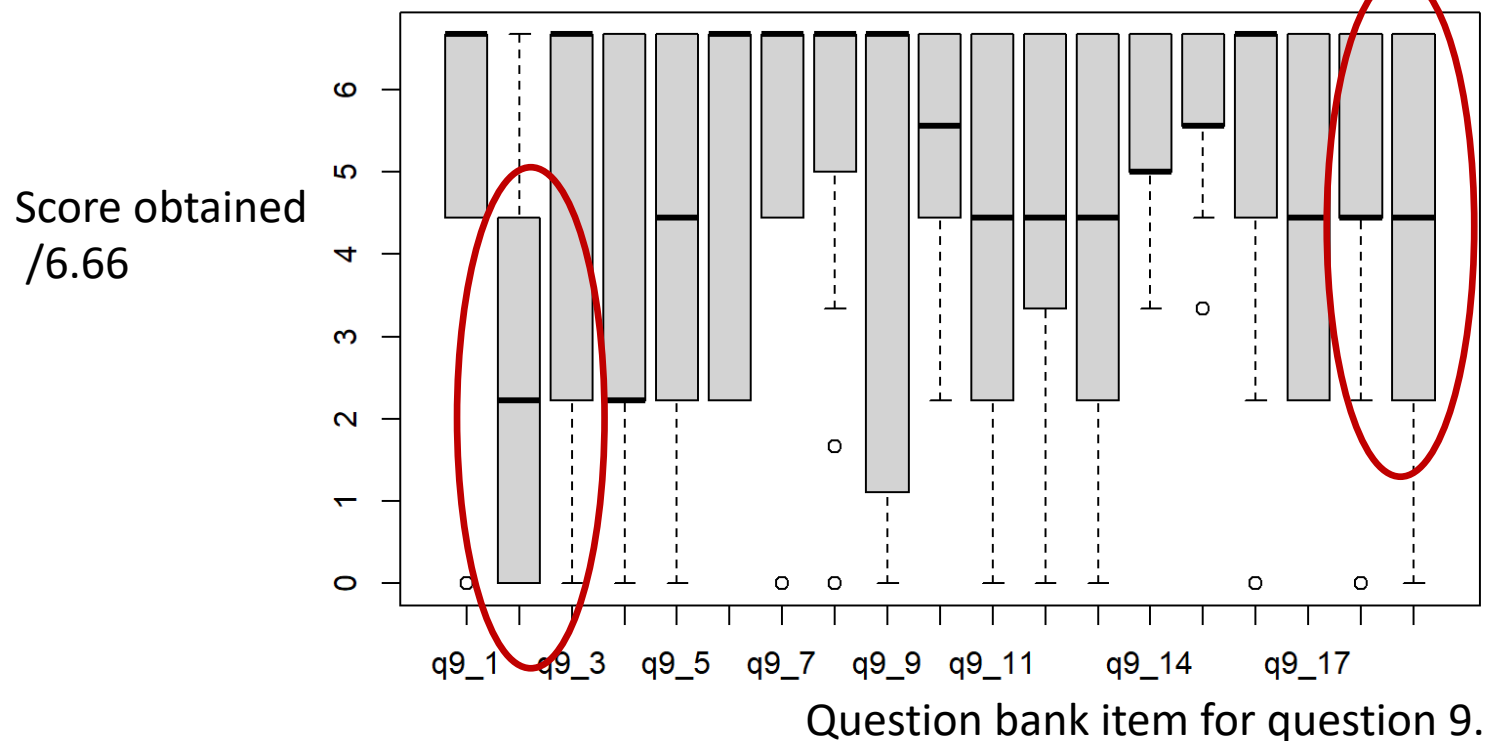
A total of [response10] groups of non-equivalent carbons (or number of signals on ¹³C-NMR)

2. Innovative assessment: Milestones – Designing meaningful questions

What if we add questions they've never seen before.

Same wording or different wording

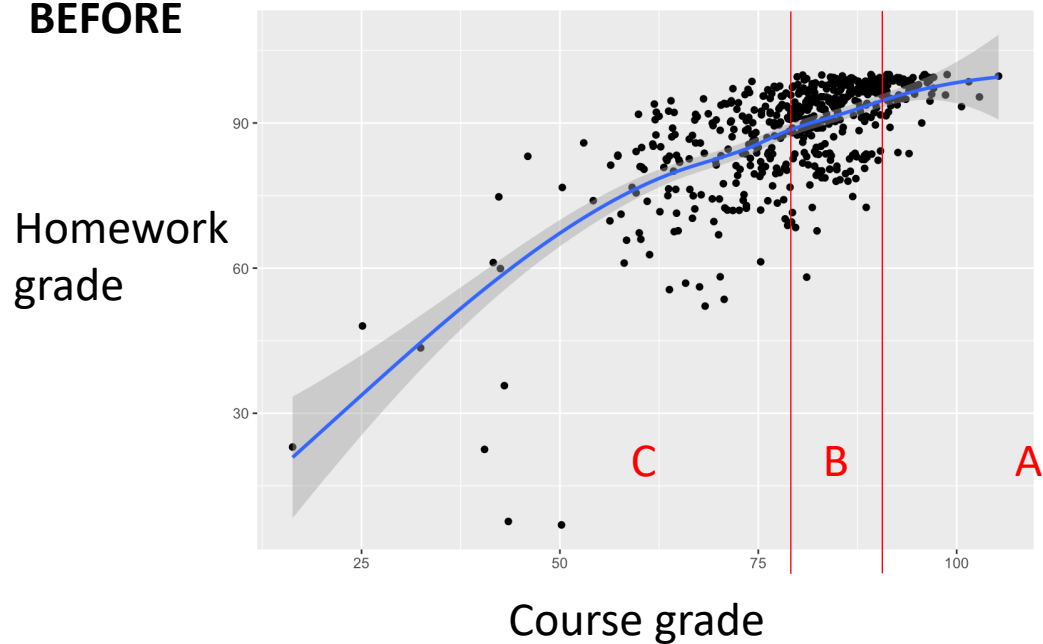
All students took these two new questions that were not available for practice
And yet, students performed equally well.



Some questions seem specifically harder even if students had access to it before.

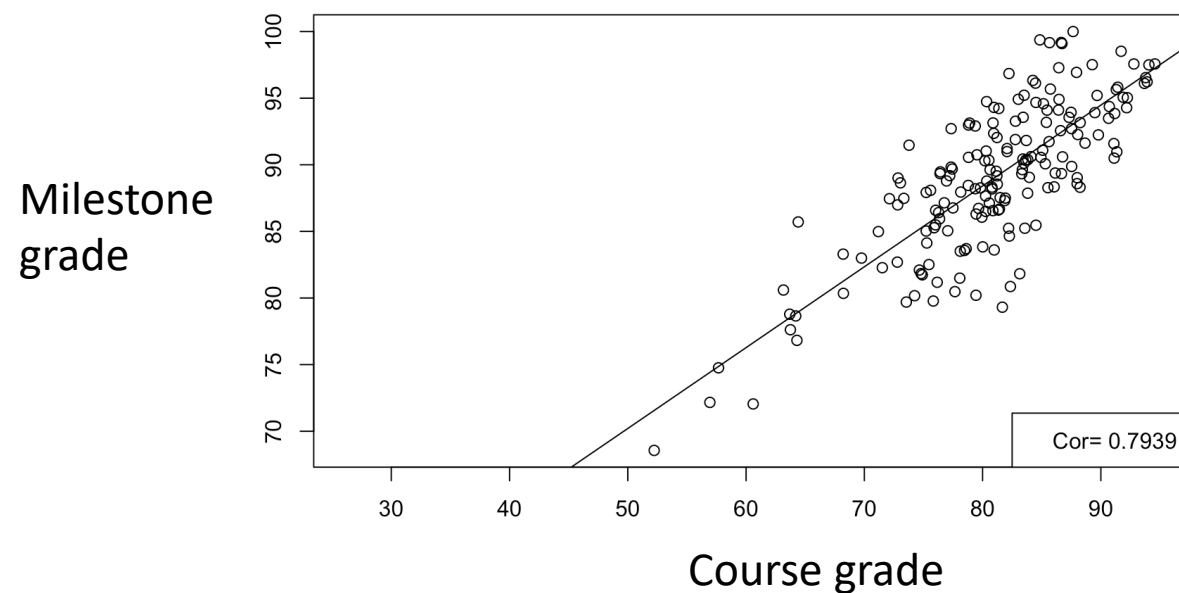
2. Innovative assessment: Milestones

BEFORE



Students complete homework for the points but not for the help to prepare for exams.

AFTER

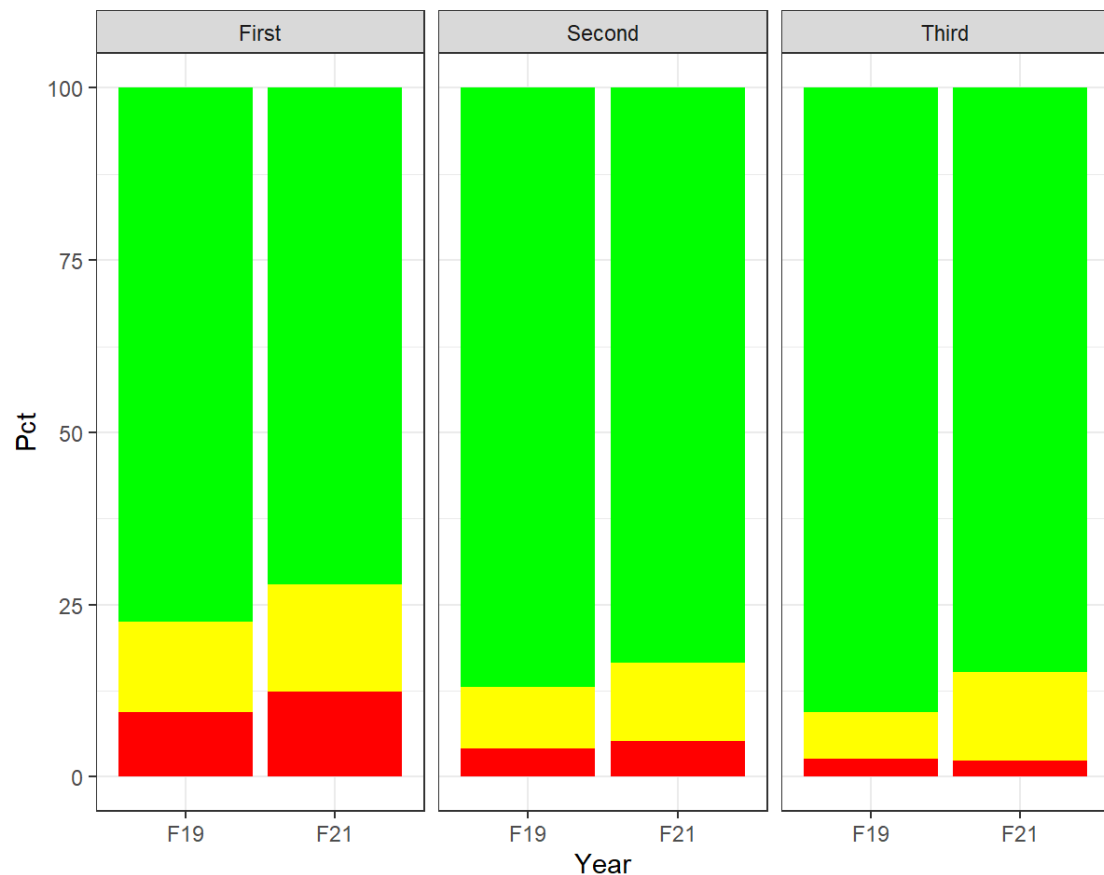


Fall 2019:
Milestones are better aligned with course grades

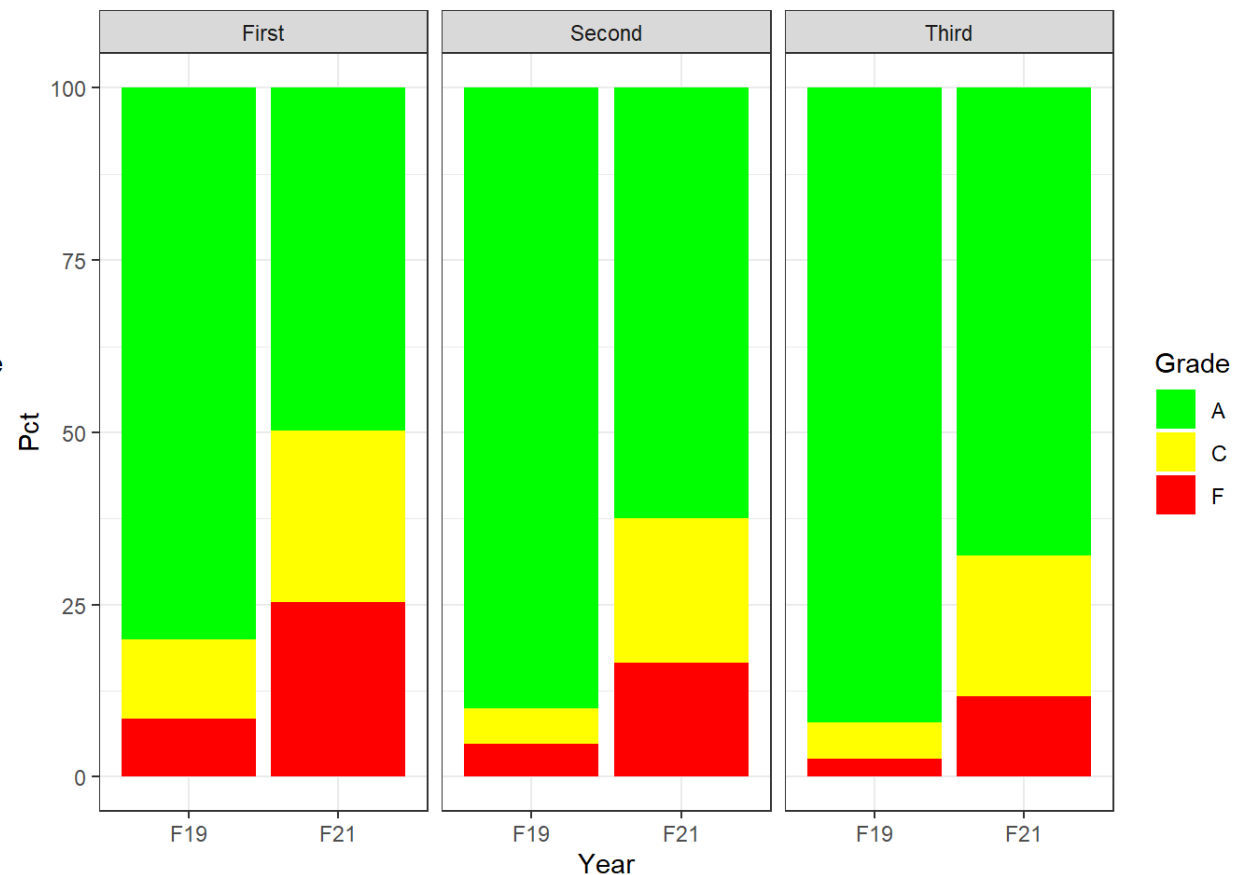
* Data belongs to 7 semesters of General Chemistry. Homework being 15% of grade.

2. Innovative assessment: Milestones – A tool for quick feedback – Comparing pre-COVID and post-COVID

Milestone 1: end of September

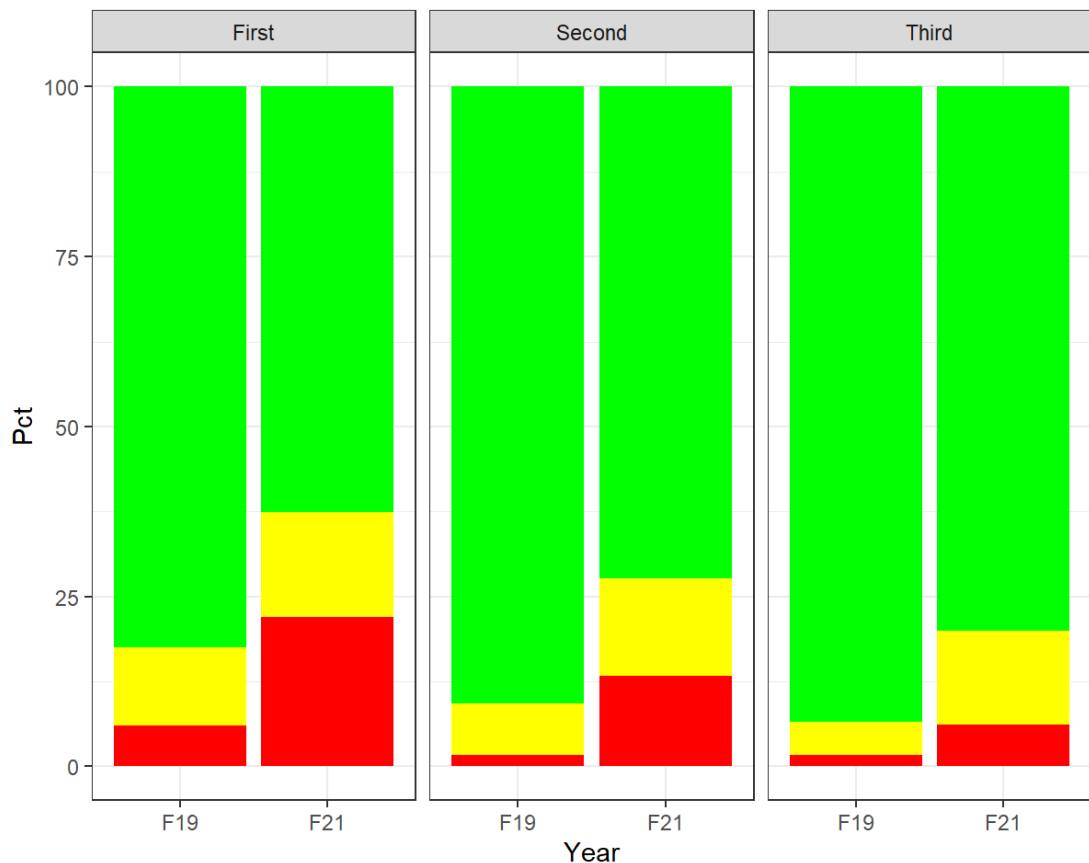


Milestone 2: mid October

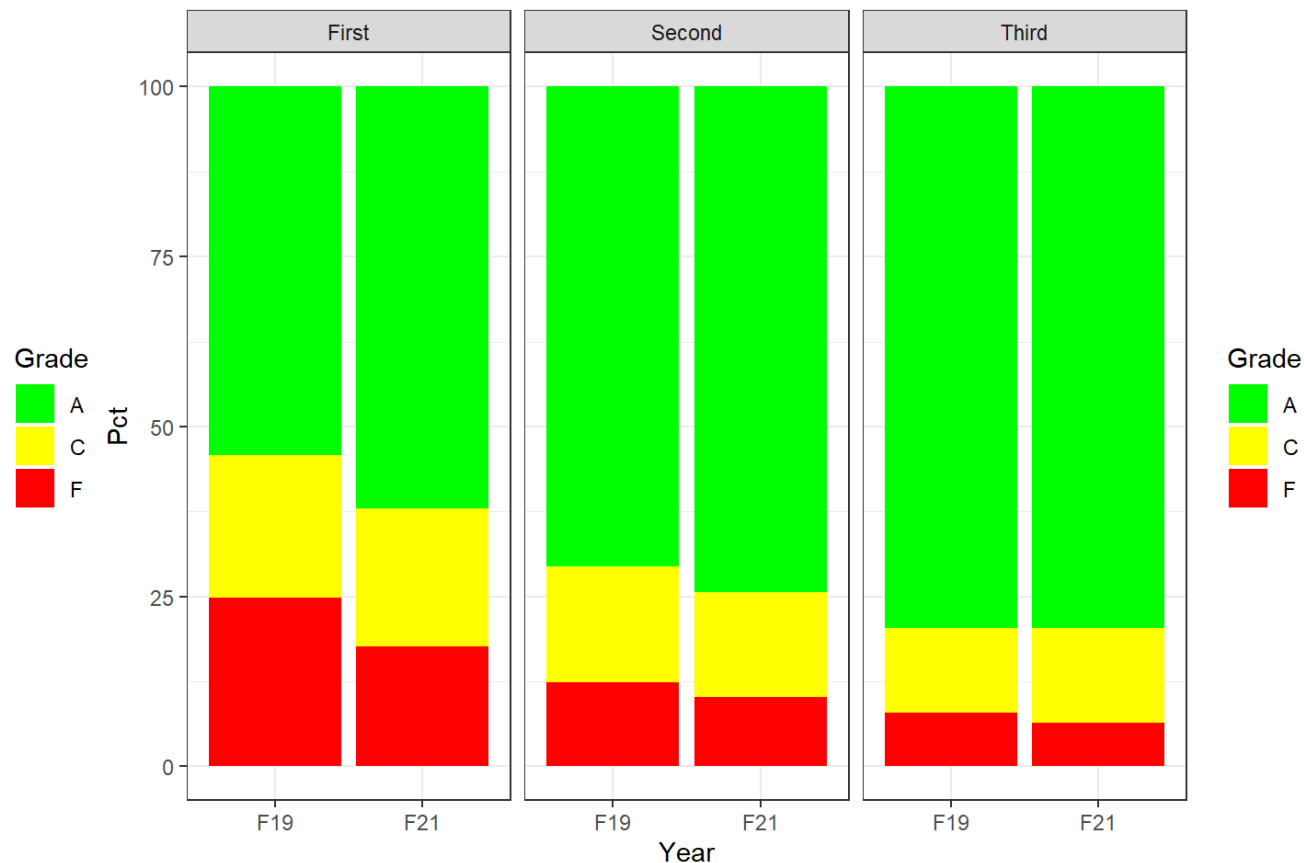


2. Innovative assessment: Milestones – A tool for quick feedback

Milestone 3: mid November



Milestone 4: beginning of December



Milestone grades send a LOUD sign.

Thanks to early signals of failure several people changed behavior or dropped the course.

By the end of the semester pre and post-covid cohorts performed similarly

2. Innovative assessment: Milestones – A tool for measuring resilience

Milestone 1

Students settling
before 3rd attempt (F21
/ F19)

	Score < 70 (F21)	Score < 70 (F19)	70< Score < 80 (F21)	70< Score < 80 (F19)
Settled in 1st attempt	3	2	7	4
Settled in 2nd attempt	0	3	13	5
Total	3	5	20	9

Milestone 2

Settled in 1st attempt	2	3	14	2
Settled in 2nd attempt	5	0	11	4
Total	7	3	25	6

Three or four times as many students settled in F21 compared to F19.

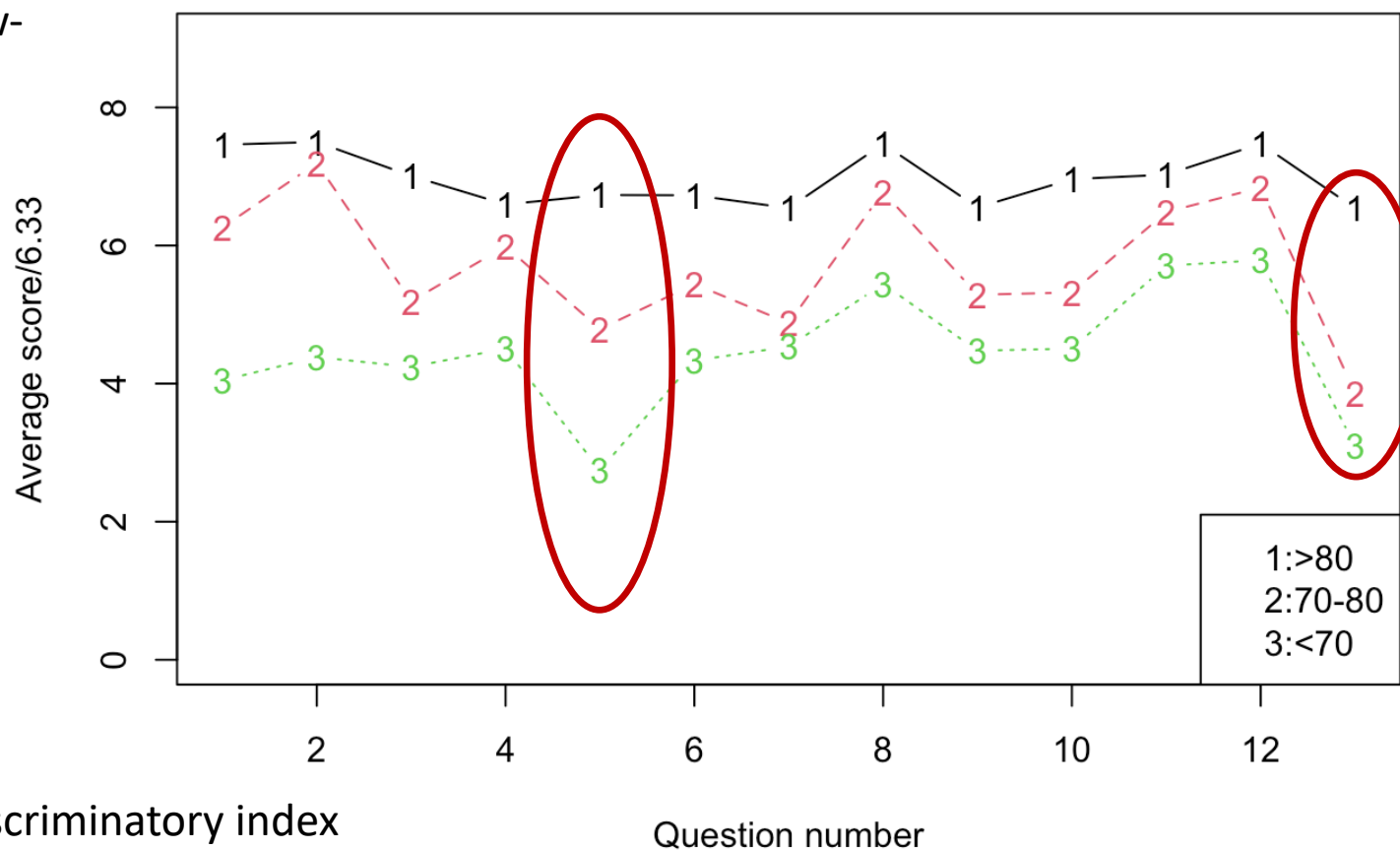
Milestone 3

Settled in 1st attempt	4	2	7	3
Settled in 2nd attempt	3	0	7	2
Total	7	2	14	5

2. Innovative assessment: Milestones – Feedback to students

There are questions that are harder only to low-performers.

M3: Average score per question on 1st attempt

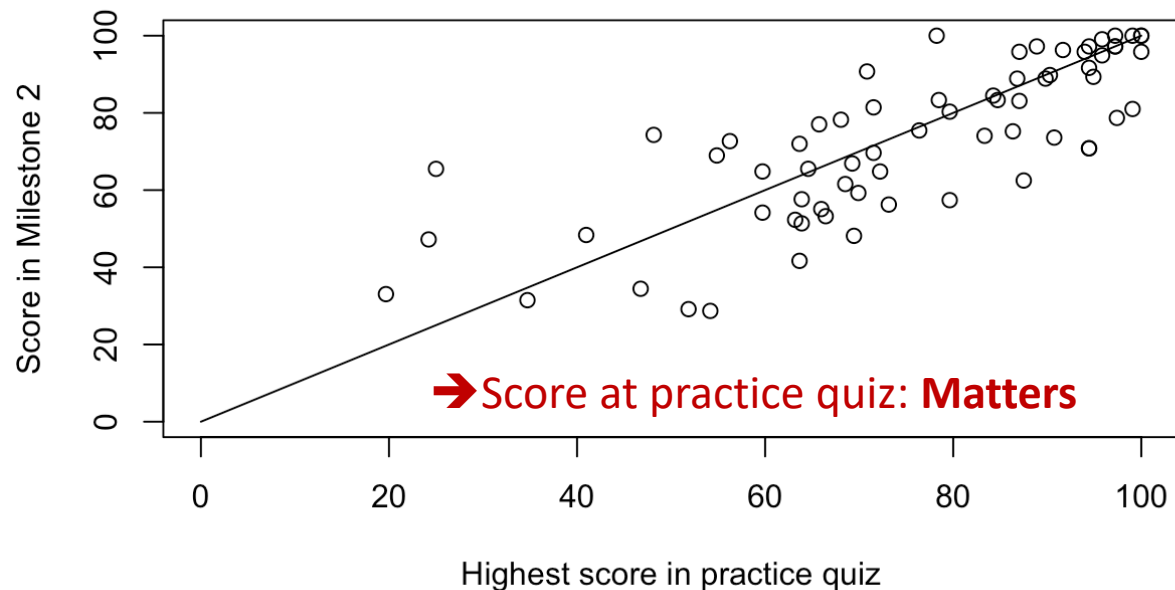


Questions with a high discriminatory index

- ➔ Help predict college performance
- ➔ Informs students about pitfalls

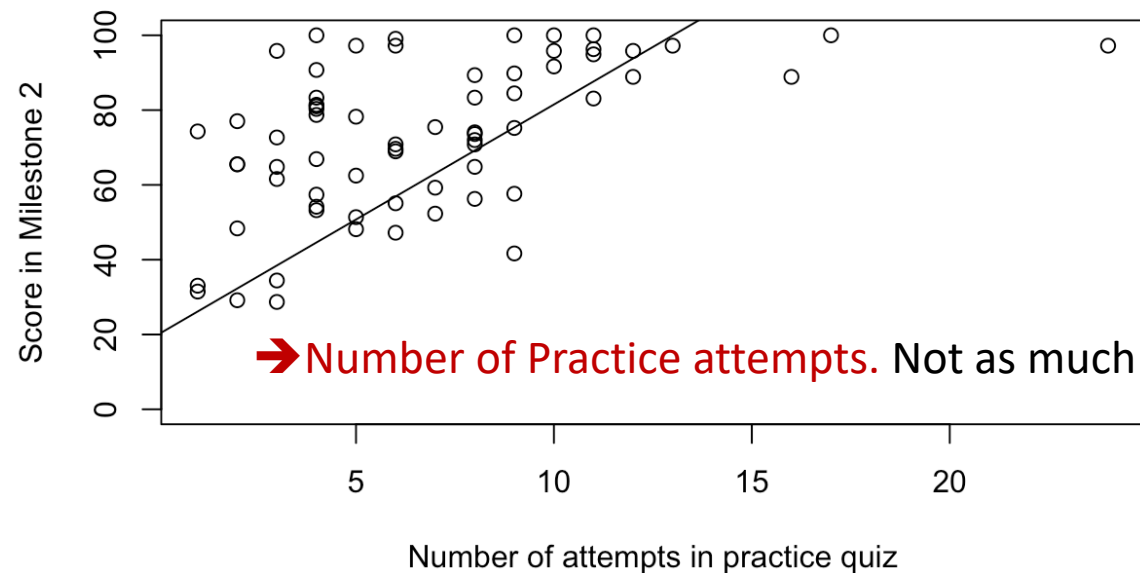
2. Innovative assessment: Milestones – Feedback to students

Milestone 2. Practicing score

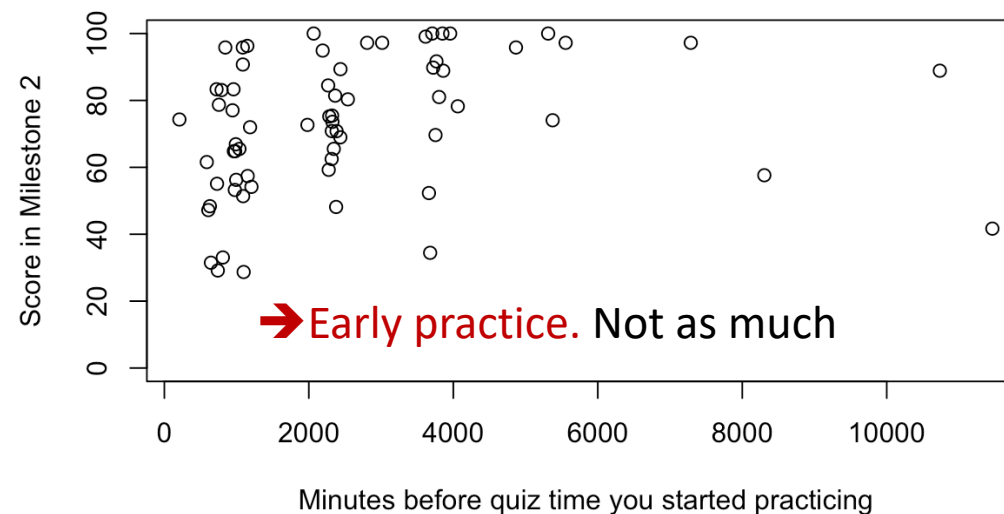


- Practice at least 3 times
- Obtain a passing grade in your practice
- Applicable to sophomores (GenChem2)

Milestone 2. #Attempts



Milestone 2. Early practice



Conclusions + Lessons learned

1) A new chemistry curriculum for health sciences

- ➔ Introduce organic structures early, with Lewis structures
- ➔ Add NMR and IR as a form of experimental evidence since first semester.
- ➔ Functional groups add richness in polarity and phase change.
- ➔ Revisit topics throughout the four-semester sequence with milestones.

2) Innovative Assessment: Milestones

- ➔ Identify in your course the low-order skills that they should master.
- ➔ Give them the question bank ahead of time and make it graded on A/C/F scale.
- ➔ Use it to revisit fundamental concepts throughout the semesters.
- ➔ Use the results as a tool for quick feedback and send early signs of failure.



Thanks to our chemistry team:
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Thanks.

BCCE

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