CEGEP to University Transition Workshop

S4 Team: Jean-François Brière, Caroline Cormier, Sean Hughes, Karl Laroche, Carmen Leung & Véronique Turcotte

Supported by SALTISE

January 10, 2022, 9am-12pm

1. Welcome, the Team and goals (10 mins)
2. Introduction to the new CEGEP Science Program (10 mins)
3. Key differences in the new program (20 mins)
4. Intradisciplinary discussions in breakout rooms (45 mins)
5. Break (10 mins)
6. Sharing of key points from discussions (30 mins)
7. Inquiry-based labs (20 mins)
8. Wrap up (5 mins)

Goals

By the end of this workshop:

- Better understanding of the new science program
- Discipline specific opportunities and challenges
- What universities can expect from the exit profile of a CEGEP student
- Introduction to inquiry-based labs
- Start of a continued conversation between peers

The new cegep Science program

Opportunities and challenges

Caroline Cormier

Six new goals : Upon completion of their studies in Science, students will be able to:

1. Use discipline-specific knowledge to consolidate and enrich one's general scientific knowledge
2. Analyze and solve complex situations from an interdisciplinary perspective.
3. Appreciate the connections between the sciences, technology, and society.
4. Demonstrate critical thinking and intellectual rigour.
5. Use digital technology in a scientific context.
6. Develop a spirit of collaboration and communicate

Expectations from university faculty (excerpts from consultations 2014-2017)

Knowledge integration	Scientific thinking and autonomy
• "[science faculty] consider that students have not adequately integrated disciplinary knowledge" (ÉduConseil, 2014, p. 39) • "Integration of learning is at the heart of universities' concerns, both disciplinary and cross-disciplinary" (Belleau, 2017, p. 19).	• "[cegep graduates] are accustomed to following predetermined protocols and are caught off guard when faced with an open-ended problem, which they must solve by figuring out how to proceed on their own" (ÉduConseil, 2014, p. 40). • "the primary goal of laboratory learning is to develop autonomy in learners through, among other things, greater ownership of the laboratory protocol" (Belleau, 2017, p. 17)

What to do with the new program?

The exit profile, an opportunity	To respond to the expectations of universities While building on the results of educational research
It requires working in program approach	Vertically in a discipline Horizontally across disciplines
To devise a learning progression to teach science process skills	i.e. data interpretation, problem solving, experimental design, scientific writing, oral communication, collaborative work, and critical analysis of primary literature

(Coil et al., 2010)

The basis for a reflection on exit profile

Depth vs. Breadth

- Move away from 'The Tyranny of Coverage'
- Identify the core concepts and competencies
- Teach the process of science to develop scientific skills

Petersen et al., (2020); Schwartz, Sadler, Sonnert, & Tai (2009); Coil, Wenderoth, Cunningham, & Dirks (2010)

Training scientists vs. Educating citizens about science

Two of the goals of the program are:

- Appreciate the connections between the sciences, technology, and society.
- Analyze and solve complex situations from an interdisciplinary perspective.

MÉES (2021) *Sciences de la nature (200.B1), Programme d'études préuniversitaires, Enseignement collégial.*

THE PROGRAM IS ONLY ONE ACTOR, YOU HAVE THE POWER!

TEACHERS ARE MAKING THE DECISIONS

Educational experience should be made coherent using the program approach to develop science process skills (Lavoie et al., 2019); this requires focusing on the goals of the program rather than just those of the course (Barnett, Parry, & Coate, 2001).

The tremendous potential of a coherent curriculum approach could also allow space to address social scientific issues, which require input from more than one discipline.

Further reading:

Cormier, C., & Voisard, B. (accepted). Nouveau programme collégial québécois de Sciences de la nature : Commentaire sur l'article de Désautels (2020) et pistes pour l'intervention. *Canadian Journal of Science, Mathematics and Technology Education*.

Main Features & Key Differences

Jean-François Brière

Variation in hours: Health Sciences

	Discipline	Old program	New program	Variation
Mandatory competencies	Biology	150	165	+15
	Math	225	240	+15
	Chemistry	225	195	-30
	Physics	225	210	-15
	Computer science	0	45	+45
	Integrative	0	45	+45
Optional competencies	All disciplines	75	0	-75
Total		900	900	0

Variation in hours: Pure and Applied Sciences

	Discipline	Old program	New program	Variation
Mandatory competencies	Biology	75	105	+30
	Math	225	240	+15
	Chemistry	150	135	-15
	Physics	225	210	-15
	Computer science	0	45	+45
	Integrative	0	45	+45
Optional competencies	All disciplines	225	120	-105
Total		900	900	0

New program is more prescriptive

The old program had competencies, **elements of competencies** and **performance of criteria for the competency**.

The new program also has **performance criteria for each element of competency**.

We can expect less variations in content between colleges.

Code : 00UR

Objectif	Standard
Énoncé de la compétence Analyser différentes situations et phénomènes physiques à partir des principes fondamentaux reliés à la mécanique classique.	
Éléments de la compétence	**Critères de performance**
1. Décrire le mouvement de translation et de rotation des corps. 2. Appliquer les concepts et les lois de la dynamique à l'analyse du mouvement des corps. 3. Effectuer des calculs de travail et d'énergie dans des situations simples. 4. Appliquer les principes de conservation de la mécanique. 5. Vérifier expérimentalement quelques lois et principes reliés à la mécanique.	• Utilisation appropriée des concepts, des lois et des principes. • Schématisation adéquate des situations physiques. • Utilisation d'une terminologie appropriée. • Représentation graphique et mathématique adaptée à la nature du mouvement. • Justification des étapes retenues pour l'analyse des situations. • Application rigoureuse des lois de Newton et des principes de conservation. • Jugement critique des résultats. • Interprétation des limites des modèles. • Expérimentation minutieuse. • Présence des éléments constituants d'un rapport de laboratoire selon les normes établies.

Old program

Code : 0P01

Objectif	Standard
Énoncé de la compétence Analyser des situations et des phénomènes physiques en recourant aux lois et aux principes fondamentaux de la mécanique classique.	**Critères de performance liés à l'ensemble de la compétence** • Utilisation appropriée de la terminologie. • Respect du formalisme mathématique. • Utilisation et conversion d'unités de mesure appropriées. • Schématisation claire de la situation à analyser. • Distinction juste des quantités physiques associées à la mécanique classique. • Démonstration de rigueur dans la démarche de résolution de problèmes. • Manifestation d'un jugement critique à l'égard de la vraisemblance des résultats.
Éléments de la compétence	**Critères de performance**
1. Effectuer l'analyse de situations et de phénomènes physiques en recourant aux concepts de la cinématique de translation et de rotation.	• Calcul exact des quantités physiques associées à la cinématique. • Détermination graphique juste des quantités physiques liées à la cinématique. • Application rigoureuse des concepts et des équations de la cinématique propres au type de mouvement. [1] • Résolution correcte de problèmes liés à la cinématique.
2. Effectuer l'analyse de situations et de phénomènes physiques en recourant aux lois de la dynamique de translation et de rotation.	• Présentation de diagrammes des forces complets et exacts. • Calcul exact des quantités physiques associées à la dynamique. [2] • Application rigoureuse des lois de Newton à des corps en mouvement. [3] • Application rigoureuse des conditions de l'équilibre statique à des corps rigides au repos. • Résolution correcte de problèmes liés à la dynamique.
3. Effectuer l'analyse de situations et de phénomènes physiques en recourant à des principes de conservation.	• Calcul exact du travail et des quantités physiques associées à l'énergie. [4] • Application rigoureuse du principe de conservation de l'énergie à des systèmes. [5] • Calcul exact de la quantité de mouvement et du moment cinétique. • Application rigoureuse des principes de conservation de la quantité de mouvement et du moment cinétique à des systèmes. • Résolution correcte de problèmes liés aux principes de conservation.
4. Vérifier, par une démarche expérimentale, des lois et des principes liés à la mécanique classique.	• Utilisation appropriée des techniques, du matériel de laboratoire et des instruments de mesure. • Traitement approprié des données. [6] • Pertinence de l'analyse et justesse des résultats. • Communication des résultats selon les exigences attendues. • Collaboration efficace dans le travail d'équipe.

New program

Main losses with the new program

- Reduction in content of the mandatory competencies in biology, math, chemistry and physics.
  - More details in the discipline-specific group discussions.
- Number of optional courses reduced by one.
  - Health: from 1 to 0; Pure and Applied: from 3 to 2
  - Organic Chemistry II will probably no longer be offered.
- Probable reduction from 75 to 60 hours for all option courses.
  - Organic Chemistry I, Calculus III, Engineering Physics
- Technically the new competency for the general option courses, 0GNF, is of at least 60 hours.
  - It would be possible to have a single option course of 120 hours…

Main gains with the new program

All students will have:

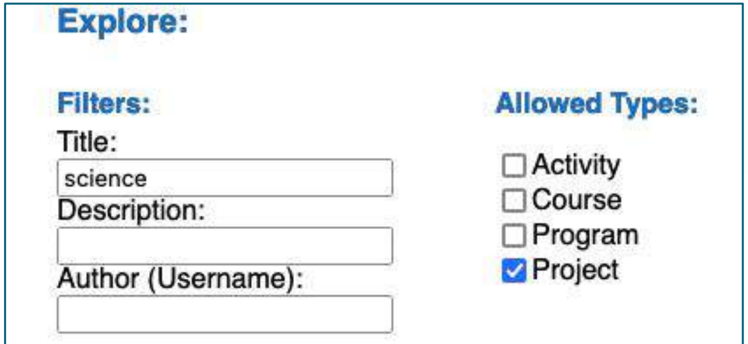
- a **computer programming** course aimed at applications in science.
  - 0F01 Develop computer programs in order to automate problem solutions in a scientific context. (45 hours)
- a **probability and statistics** course aimed at applications in science.
  - 0M01 Solve problems in the fields of natural sciences with the use of statistical methods and the concept of probability.(45 hours)
- a **project-oriented integrative course**
  - 0NTC Demonstrate the integration of one's acquired skills within science. (45 hours)

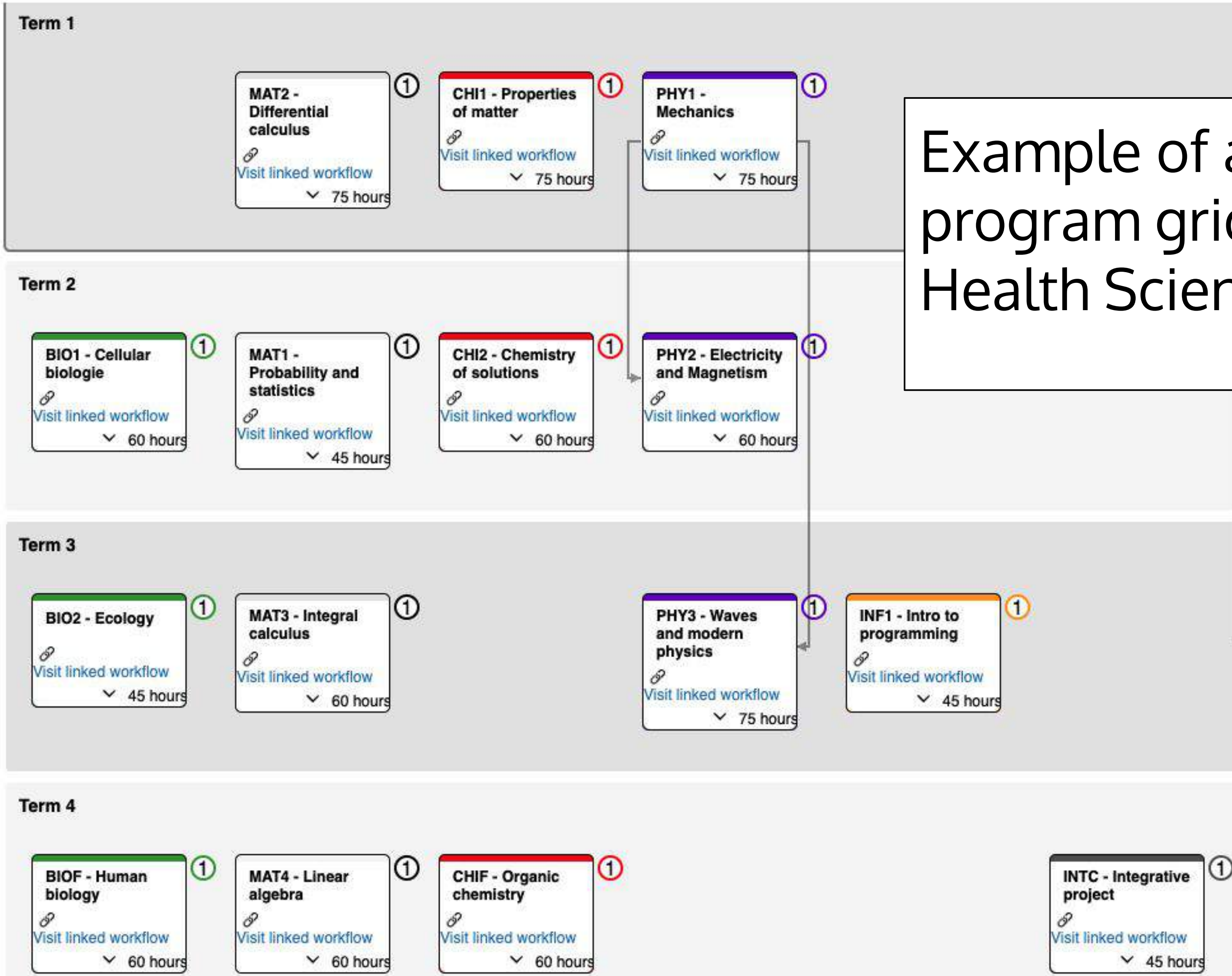
Hopefully, this will better equip students to perform scientific inquiries.

Playing with courses, competencies and goals.

- A template of the program is available on the CourseFlow platform.
    - To access CourseFlow you need an account on the Saltise or myDALITE platform.
    - To create an account: https://mydalite.org/en/signup/

- Search for 'Science' while selecting 'Project' from the explore menu.
    - A detailed 'how-to' will be available shortly.





Example of a possible program grid for the Health Sciences profile.

Intradisciplinary Discusssions

Join a breakout room:

- Biology - Karl Laroche
- Chemistry - Sean Hughes
- Math - Kevin Davis
- Physics & Engineering - J.F. Briere

Intradisciplinary Discusssions

Breakout Room Agenda

- Key differences between the old and new program
- SWOT analysis (strengths, weakness, opportunities & threats) for the transition from CEGEP to University
- Specific opportunities and challenges the new program poses for university programs
- and maybe....brainstorm of ideas for 0NTC (integrative project)

Biology

Karl Laroche

Biology - Discussion Points

- We discussed prerequisites for admission to university health- and life-science-related programs, and questioned whether the optional Biology and Chemistry competencies (0B0F, Anatomy and Physiology; 0C0F, Organic Chemistry) would actually be required. If they aren’t, it opens up options for the development of other courses in CEGEP, and for students interested in “Health Science” to have an opportunity to choose other option courses. Further discussions are required with universities to determine exactly what their entrance requirements will be.
- We lamented the high amount of content (given the number of allocated course hours) and how difficult it will be to explore any topic in depth.
- We discussed the ideal order to present the Biology courses, and several colleges indicated that they were considering presenting the second competency (0B02) first in their course grid.

Chemistry

Sean Hughes & Carmen Leung

Old Program vs New Program

Old

Code: 00UL

Objective	*Standard*
Statement of the Competency	
Analyze chemical and physical changes in matter using concepts associated with the structure of atoms and molecules.	
Elements of the Competency	**Performance Criteria**
1. Apply the probabilistic model of the atom in analyzing the properties of the elements. 2. Solve problems pertaining to the structure and states of matter using modern theories of chemistry. 3. Apply the laws of stoichiometry to the study of chemical phenomena. 4. Verify experimentally a number of physical and chemical properties of matter.	• Proper use of concepts, laws and principles • Use of appropriate terminology • Representation in conformity with the probabilistic model • Adequate representation of situations presented • Correct application of experimental procedures and techniques • Adherence to safety and environmental protection regulations • Accuracy of calculations • Laboratory report in line with established standards

Learning Activities

Discipline: Chemistry
Weighting: 3-2-3
Credits: 2⅔
Periods of instruction: 75
Indications: Orbitals and probability of presence of electrons, quantum numbers.
Elements: periodic table, normal physical state, periodic properties of elements, oxidization numbers.
Terminology of elements and inorganic compounds.
Energy in the formation of chemical bonds.
Intermolecular bonds.
Prediction of molecular structures.
Intermolecular bonds and states of matter.
Basic experimental techniques in chemistry.

New

Code : 0C01

Objectif	*Standard*
Énoncé de la compétence	**Critères de performance liés à l'ensemble de la compétence**
Analyser des propriétés de la matière et des transformations chimiques.	• Utilisation appropriée de la terminologie. • Respect du formalisme mathématique et chimique. • Utilisation et conversion d'unités de mesure appropriées. • Prise en compte d'enjeux environnementaux. • Démonstration de rigueur dans la démarche de résolution de problèmes.
Éléments de la compétence	**Critères de performance**
1. Utiliser le langage et la symbolique chimiques.	• Utilisation pertinente des concepts de base et de la symbolique chimique. [1] • Application juste des règles de nomenclature inorganique.
2. Effectuer l'analyse de systèmes chimiques d'un point de vue quantitatif.	• Application juste de concepts appropriés dans les calculs de quantités utilisées en chimie. [2] • Application juste des règles de la stœchiométrie à différents types de réactions. [3]
3. Expliquer les propriétés des éléments et leurs liens avec la classification périodique.	• Description appropriée des principales caractéristiques du modèle probabiliste de l'atome. • Description appropriée des orbitales atomiques et des configurations électroniques par le recours aux nombres quantiques. • Démonstration sommaire des liens entre les configurations électroniques et les propriétés chimiques des éléments. [4] • Explication juste des principales propriétés périodiques des éléments. [5]
4. Expliquer la structure de la matière selon les types de liaisons chimiques.	• Distinction juste des types de composés selon le type de liaisons impliquées. [6] • Calculs précis impliquant les énergies de liaisons covalentes. • Détermination appropriée de la structure de molécules et d'ions polyatomiques. [7] • Description juste de l'hybridation des orbitales atomiques. [8]
5. Expliquer les principales propriétés macroscopiques de la matière.	• Distinction juste des forces intermoléculaires. • Détermination juste de l'intensité relative des forces intermoléculaires. • Démonstration juste de la relation entre les propriétés physiques de la matière et les forces impliquées. [9]
6. Vérifier, par une démarche expérimentale, des propriétés chimiques et physiques de la matière.	• Utilisation appropriée des techniques, du matériel de laboratoire et des instruments de mesure. • Respect des règles en matière de santé et de sécurité au laboratoire ainsi que de protection de l'environnement. • Traitement approprié des données. [10] • Pertinence de l'analyse et justesse des résultats. • Communication des résultats selon les exigences attendues. • Collaboration efficace dans le travail d'équipe.

Very specific learning activities

Activités d'apprentissage

Discipline : Chimie
Pondération : 3-2-3
Unités : 2 ⅔
Périodes d'enseignement : 75
Précisions :

Précisions supplémentaires sur les contenus

[1] Concepts et symbolique chimiques :
- atomes, isotopes, ions et molécules;
- numéro atomique et nombre de masse;
- charge et nombre d'oxydation;
- formules chimiques (empirique et moléculaire);
- types d'éléments : métaux, non-métaux, et métalloïdes;
- états physiques.

[2] Concepts et quantités :
- masse atomique, masse molaire et nombre de moles;
- masse volumique, concentrations et unités de concentration.

[3] Règles de la stœchiométrie :
- équilibrage d'équations incluant oxydoréduction;
- calcul impliquant un réactif limitant et calcul de rendement.

[4] Propriétés chimiques :
- types d'ions formés (charge, valence);
- inertie chimique et réactivité.

[5] Propriétés périodiques :
- rayon atomique;
- énergie de première ionisation;
- électronégativité.

[6] Types de composés :
- composés ioniques;
- composés moléculaires, y compris quelques polymères.

[7] Structure :
- diagramme de Lewis-Pauling, y compris les exceptions à la règle de l'octet et la résonance (avec ions polyatomiques et molécules organiques simples);
- structure tridimensionnelle par le recours à la théorie de la répulsion des paires d'électrons de valence (RPEV).

[8] Hybridation :
- types : sp, sp^2 et sp^3;
- recouvrement des orbitales atomiques (σ et π).

[9] Propriétés physiques :
- températures de fusion et d'ébullition.

[10] Traitement des données :
- utilisation d'outils informatiques;
- évaluation des incertitudes;
- traitement mathématique;
- représentation graphique avec courbe de tendance.

Detailed performance criteria

General Chemistry (0C01)

- Not much has changed
- Electron affinity not listed under periodic properties

Chemistry of Solutions (0C02)

- 60 hours instead of 75 hours
  - 20% reduction of contact time (5 weeks of ‘theoretical class’)
- Ponderation is 2-2-2
- Removed:
  - Osmotic pressure and Raoult’s Law

Organic Chemistry 1 (0C0F)

- 60 hours instead of 75 hours
  - 20% reduction of contact time (5 weeks of 'theoretical class')
- Ponderation is 2-2-2
- Removed:
  - Free radicals
  - Organomagnesiums
- Added:
  - Aromatic Family - under 'Correct recognition of the reactivity of the main families of organic compounds'
    - But there's no time to teach electrophilic aromatic substitution.....

Organic Chemistry 2 will likely not be offered

Chemistry - Discussion Points

Weaknesses / Threat

- No thermodynamics or thermochemistry - university faculty disappointed (Gibb's energy tied in with acid-base and chemical equilibrium)
- Thermodynamics important for physics and engineering
- Potential loss of Organic 1 equivalency in university (but could possibly have Org 1 ***lab*** equivalency at McGill)
- Not just losing hours in courses, also losing option courses
- Integratable components have been cut from the program - e.g. osmotic pressure (seen in Biology) and Raoult's Law

Strengths / Opportunities

- We can make a good GENF course that focus on engineering chemistry (electrochem, thermos, vapor pressure and distillation methods)
- Opportunities - better coordination/discussions between Chem and Bio as well as Chem and other programs for Pure and Applied
- Stats - improves data analysis skills
- Bringing colleagues together from different institutions to start discussion. We all have the same goal!

Chemistry - SWOT

Strengths	**Weaknesses**
1. Emphasis on interdisciplinary interaction and getting out of our silos	1. Integratable components have been cut from the program; osmotic pressure, interparticle forces 2. No thermodynamics or thermochemistry - University faculty disappointed (Gibb’s energy tied in with acid-base and chemical equilibrium) 3. Still spending a large amount of time for high school review 4. Titration curve analysis not specifically included as a performance criteria (was present in v2020 draft) 5. Colligative properties - osmotic pressure (seen in Biology) and Raoult’s Law removed. No covalent bonding network 6. No electrochemistry (electrochemical cells), however students will still get equivalency at McGill for Gen Chem. 7. Thermodynamics important for physics and engineering
Opportunities	**Threats**
1. Bringing colleagues together from different institutions to start discussion. We all have the same goal! 2. We can make a good GENF course that focus on engineering chemistry (electrochem, thermos, vapor pressure and distillation methods) 3. Opportunities - better coordination/discussions between Chem and Bio as well as Chem and other programs for Pure and Applied 4. Stats - improves data analysis skills	1. Potential loss of Organic 1 equivalency in university 2. Not just losing hours in courses, also losing option courses

Other points that came up:

- Universities expect just an introduction to redox (more in depth knowledge when in universities)
- Electrophilic aromatic substitution benchmark for McGill equivalency. If it's not covered in Cegep course, then currently no equivalency. Based on new program, Universities may rethink what to do with their current course offerings (e.g. reorganize the content between courses, create new course, etc.)
- Suggestion to use lab period to cover some 'missing' topics - e.g. calorimetry to keep some thermochemistry.
- Emphasis on speaking to other departments to see which chemistry topics can be integrated into other disciplines.
  - Biology - how much is redox shown? Provides reason for a little more emphasis on the topic in Chem 1 and 2 courses.

Math

Kevin Davis

Math - Discussion Points

New statistics course

- Basic, solid introductory stats course geared toward preparing students to be statistically proficient in their Science courses.
- Needs to happen early in the program to serve its purpose.
- Could be connected with the new Computer Science course with statistical coding problems.
- Exciting to have stats in the program!

Calculus I

- Calculus I is not significantly changed in content from the current course, and has the same number of hours.
- May need to cover some of the topics listed in Calculus II (see below).

Math - Discussion Points

Calculus II

- Calculus II has slightly more content than the current course, but 15 fewer hours. In other words, the course with the lowest success rate in the program has been made significantly harder. This is untenable and we are uncertain how best to handle it.
- One possible partial solution would be to shift some topics listed in Calculus II to Calculus I because of the greater hours in Calculus I. This would of course make Calculus I harder, but would balance the overall workload with Calculus II more evenly. This is of course not an ideal solution, and would require some level of harmonization with other cegeps to ensure equivalence of courses.
- One major positive addition to Calculus II is a proper treatment of Taylor series, which are very important in Physics and other Sciences.

Math - Discussion Points

Linear Algebra

- Some more abstract topics were removed, but there was a corresponding decrease in hours. Otherwise not significantly changed.

Computer Science

- This is a very exciting addition to the program!
- Solid introductory coding course with a Scientific context.
- May be possible to coordinate the Computer Science course with Mathematics or Physics courses by including scientific coding problems in assignments (depending on timing in the program).

Physics

Jean-François Brière

Changes in Mechanics (0P01)

- Still 75 hours with ponderation 3-2-3.
- Increase in the minimal content covered due to more prescriptive performance criteria.
- Now explicitly stating:
    - conservation of angular momentum
    - conservation of energy for circular and rotational motion
    - rolling motion (I think)
        - (mouvements de translation et de rotation de corps rigides autour d’un axe fixe en direction)

Changes in Electricity and Magnetism (0P02)

- Loss of 15 hours of contact time
  - From 75 hours (ponderation 3-2-3) to 60 hours (pond. 2-2-2)
- **Decrease** in the minimal content covered due to more prescriptive performance criteria.
- Topics explicitly removed:
  - Continuous charge distributions
    - My interpretation is that integrals are pretty much out…
  - Inductance, RL and RLC circuits
  - Gauss's laws
  - Alternative currents

Changes in Waves and Modern Phys (0P03)

- Still 75 hours with ponderation 3-2-3.
- **Loss of content:**
  - Geometrical optics (lenses, mirrors and refraction)
  - Diffraction gratings are not mentioned.
  - Specifying that modern physics must include Quantum physics and Nuclear physics
    - Special relativity not mentioned - so excluded in practice
- **Added** content:
  - New element of competency on environmental science:
    - Transfer of energy due to conduction and radiation
    - Greenhouse effect and radiative forcing

Physics & Engineering - SWOT pt 1

Strengths	Weaknesses
1. Addition of prob/stats and computer programming with explicit applications in science. a. Opportunity to be reused in labs and projects later in the program. 2. More uniformity in content coverage across the cegeps 3. Addition of environmental topics	1. Possible variation in preparedness between students from Québec and students from elsewhere taking the freshman university courses (or for our students going abroad). 2. Loss of integration in E&M might be an issue. (Possibly fixed by using the option courses) 3. Various loss of content - not everyone agrees on which one but 'special relativity' comes back often. 4. Some feel we are even more than before under the tyranny of content (others think the opposite though). 5. Waves and modern physics will be a patchwork course. 6. An element of competency on Thermo is added to Waves, but the students do not have basic thermodynamics knowledge to start from.

Physics & Engineering - SWOT pt 2

Opportunities	Threats
1. Many new opportunities with the integrative course: a. Using Arduino/Raspberry Pi to do robotics b. could be team-taught 2. Possibility to reinvest **programming** and **statistics** skills in labs and the integrative course. 3. Use a common language across disciplines when treating uncertainties. 4. Create an option course geared towards physics and engineering and common across institutions. 5. Put E&M course on the grid without worrying about integral calculus. 6. Be more thoughtful on teaching team work and communication skills. 7. The more the interdisciplinarity is highlighted, the more the students will be open to exploring. Less of "I like Bio so I cannot be interested in physics."	1. Loss of common course codes will complicate the admission process. 2. Making sure the 6 program goals are achieved. 3. Avoid creating MEDs and creating more job insecurity. 4. Students will often have 4 science courses in a semester. Even if it is the same number of hours, the workload will likely increase. 5. Design of the integrative course will be brand new for most cégeps. a. Models to use. b. Impact on staffing. 6. Having the stats and programming course not designed for scientific applications. 7. Loss of important content due to loss of hours.

Physics & Engineering - Discussion Points

- Full ideation board available at:
  - https://miro.com/app/board/uXjVOWlOgWs=/?invite_link_id=807662527794

Break!

- 10 min
- Sharing of main discussion points from each group when we reconvene

Inquiry-Based Labs

Bridging theory and practice

Sean Hughes

Capstone course

Demonstrate the integration of one's acquired skills within science.

- **Choose a 'subject'**
- **Formulate a question**
- **Select materials / choose from an inventory**
- **Find / adapt / create a protocol**
- **Carry out protocol/study and comply with safety standards**
- **Analyze data / produce results / derive and discuss conclusions**

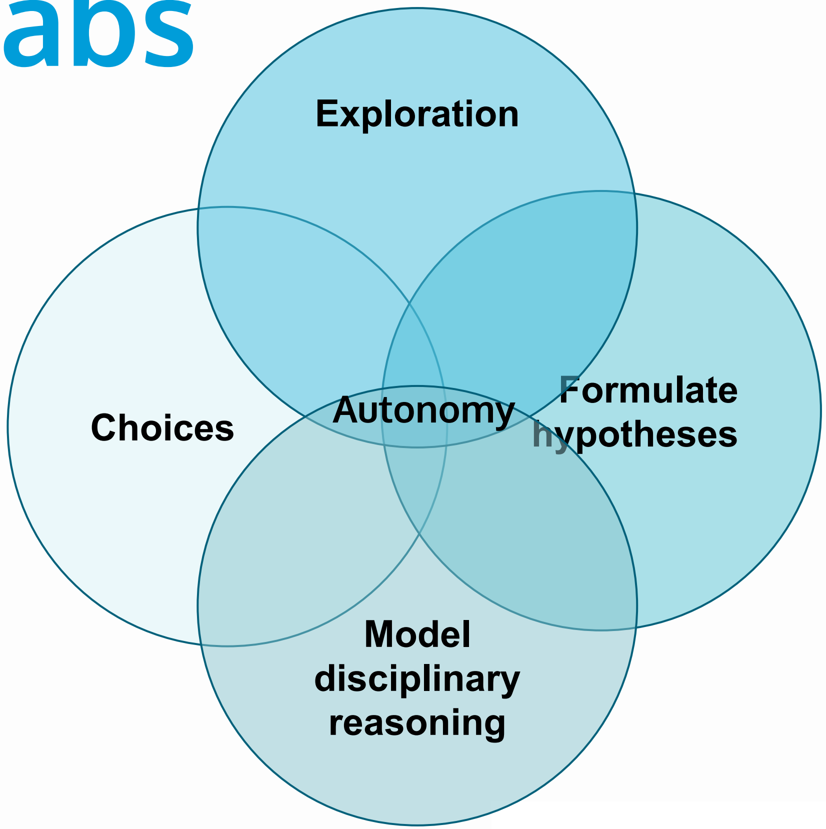
How to develop autonomy?

In lab	In class
• Ensure students can re-apply skills, techniques, experimental approaches, etc… from one semester to the next • Allow them to apply skills in other discipline	• Integration of learning (Legendre) • Combine different subjects to highlight science as a multidisciplinary domain • Incorporate into one's specific context learned knowledge and skills

Program Approach!

Inquiry-guided labs

- Laboratory activities that provide students more authentic learning experiences



Inquiry-guided labs

Traditional labs	Inquiry-guided
• To practice techniques • To learn an instrument • To verify a law or principle • To model disciplinary approaches • To collect data and analyze within the confines of a well-defined procedure	• To develop autonomy • To prepare students for more 'open' problems • To develop a better understanding of science as both as a practice and a process • To analyze and make conclusions from data with limited guidance

Guided inquiry - 3 levels

	Research question	Experimental methods	Interpretation of results
Level 1 - Verification	Teacher	Teacher	Teacher or student
Level 2 - Guided Inquiry	Teacher	Student	Student
Level 3 - Open inquiry	Student	Student	Student

Appropriate level for college students

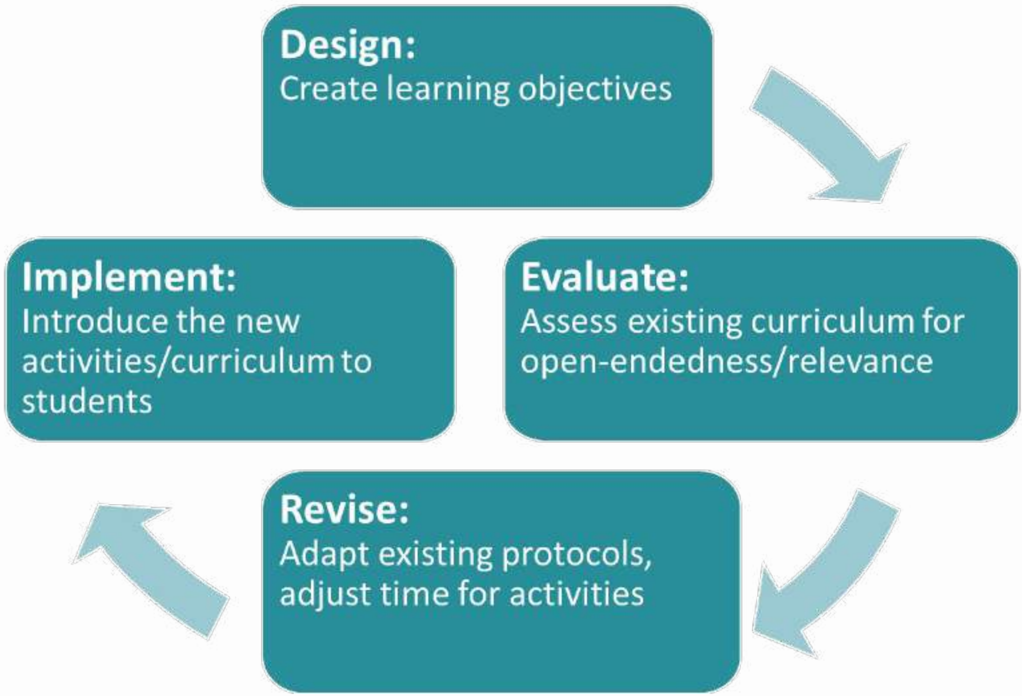
Appropriate level for graduating BSc, graduate students

(Blanchard et al.,2010; Buck et al., 2008)

The role of guidance

- Increase students' ability to engage in the task
- Simplify a complex task by providing constraints
- Motivate by adapting challenge to ability
- Provide prompts, without giving the answer
- Reduce frustration with appropriate challenge
- Demonstrate and model reasoning

Transitioning to IBL



(Farley et al.,2021)

(Cacciatore et al., 2009)

Biology lab

- Plant 'survey' lab
- Experiment set up for week 13
- Students set up the experiment, but with full instructor guidance.

Week 11 Setup

'Ecology' Lab Week 13

- Students collect data from an experimental setup with young germinated plants
- Particular study design, sampling methodology, all provided
- Students must analyze data, present results, derive conclusions, write full report

Converted to IBL

Week 11 Setup

- Remove/reduce plant survey lab
- Present theory behind experiment, basics of experimental approach
  - Germinating spores
  - Sampling method
- Students formulate hypothesis, design and set up study

Week 13 'Ecology' Lab

- Students collect data from an experimental setup with young germinated plants
- Particular study design, sampling methodology, all provided
- Students must analyze data, present results, derive conclusions, write full report

IBL in physics

- SHM lab, students determine relationship between period and amplitude of oscillations, period and mass of system using PhET simulator
- Students asked to develop methods as pre-lab, teacher provides feedback then provides procedure
- Verification lab, question and methods provided

Week 1:
Cookbook

Week 2:
More modeling

- Investigate standing wave patterns on a string, ID variables that affect harmonic frequencies
- Students propose method in pre-lab, data their method would generate is provided to students
- 'Real' procedure provided, students do lab , introduced to equipment

IBL in physics

Week 3: Cookbook

- Students explore standing waves in a pipe, measure speed of sound, ID variables affecting harmonic frequencies
- Question and methods provided to students, use equipment from lab 2

Week 4: Guided inquiry

- Students have to build either a string or pipe instrument that meets certain constraints
- Question is partially, but methods and analysis are completely open
- Students apply prior knowledge from first 3 labs, apply design principles

IBL in chemistry

Week 1: Cookbook

- Introductory experiment in colorimetry
- Objectives:
  - To handle the instruments needed for a colorimetric assay
  - To process the data

Week 4: Highly Guided-Inquiry

- Students adapt a colorimetry experiment
- Objectives:
  - To adapt a methodology from a scientific article
  - To understand the usefulness of the different steps of a colorimetric assay

Week 12: Less Guided-Inquiry

- Design a colorimetry experiment
- Objectives:
  - Write a protocol for colorimetric determination of a substance.
  - Make experimental choices (number and concentration of standards)

But what if they ‘fail’?

- Maybe it is ok
  - Make time for ‘mistakes’
  - Review lab activities, address relevance, provide opportunities for reflection
  - Reconsider what we are evaluating

Reform feedback

- Students from the current program often lack the ability to think critically, make decisions, 'think like a scientist'

- With the reform, we have an opportunity to better develop scientific autonomy through careful consideration of 'science' lab curriculum

Takeaways

- Keep discussions going between colleges and with universities (i.e. S4-discipline team meetings, CoP’s)
- Implementing new program by 2024, first cohort of graduates will be entering university in 2026
- Opportunity awaits! Now is the time to make positive change in science education

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- ....and **YOU!**

SALTISE

Today's Team

SALTISE-S4

Slides and video will be available

Contact us if you have any questions!

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