Supporting Potential AP & IB students in an NGSS Course

Sean Fisk
AP/IB/NGSS Chemistry
Ruamrudee International School, Bangkok, Thailand
Why Next Generation Science Standards?

Twitter post a few weeks ago: (paraphrased)

‘How well does NGSS prepare Chemistry Students for University Courses? Let’s hear from University Professors.’
Responses Summarized

- It's only been 4 years, calm down.
  - Students who will be freshmen in college in 2021, will have had NGSS instruction since 9th grade, in early adoption schools.
  - Most have only had a year or two of effective NGSS instruction at best

- Generally students currently arrive with:
  - Ability to memorize facts/content.
  - Inability to apply facts/content to phenomenon
  - Poor lab skills
  - Poor problem solving
“What is of paramount importance in the pre-university stage is not what is learned but learning how to learn ... What matters is not the absorption and regurgitation either of fact or pre-digested interpretations of facts, but the development of powers of the mind or ways of thinking which can be applied to new situations and new presentations of facts as they arise.”

(Peterson, 1972)
NGSS

- Disciplinary Core Ideas (Content)
- Science and Engineering Practices (Skills)
- Cross Cutting Concepts (Theme)
• Essential Knowledge (Content)
• Suggested Skill (Skills)
• Enduring Understanding related to Big Idea (Theme)
Essential idea: Elements show trends in their physical and chemical properties across periods and down groups.

<table>
<thead>
<tr>
<th>Nature of science:</th>
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<tbody>
<tr>
<td>Looking for patterns—the position of an element in the periodic table allows scientists to make accurate predictions of its physical and chemical properties. This gives scientists the ability to synthesize new substances based on the expected reactivity of elements. (3.1)</td>
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### Understandings: (Content)
- Vertical and horizontal trends in the periodic table exist for atomic radius, ionic radius, ionization energy, electron affinity and electronegativity.
- Trends in metallic and non-metallic behaviour are due to the trends above.
- Oxides change from basic through amphoteric to acidic across a period.

### Applications and skills: (Skills)
- Prediction and explanation of the metallic and non-metallic behaviour of an element based on its position in the periodic table.
- Discussion of the similarities and differences in the properties of elements in the same group, with reference to alkali metals (group 1) and halogens (group 17).
- Construction of equations to explain the pH changes for reactions of Na₂O, MgO, P₂O₅, and the oxides of nitrogen, NOₓ, as acids or bases.

### International-mindedness:
- Industrialization has led to the production of many products that cause global problems when released into the environment.

### Theory of knowledge:
- The predictive power of Mendeleev’s Periodic Table illustrates the “risk-taking” nature of science. What is the demarcation between scientific and pseudoscientific claims?
- The Periodic Table is an excellent example of classification in science. How does classification and categorization help and hinder the pursuit of knowledge?

### Utilization:
Syllabus and cross-curricular links:
- Topic 2.2—anomalies in first ionization energy values can be connected to stability in electron configuration
- Topic 8.5—production of acid rain

### Aims:
- Aims 1 and 8: What is the global impact of acid deposition?
- Aim 6: Experiment with chemical trends directly in the laboratory or through the use of teacher demonstrations.
- Aim 6: The use of transition metal ions as catalysts could be investigated.
- Aim 7: Periodic trends can be studied with the use of computer databases.
Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

- The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

The organization of the periodic table is based on the recurring properties of the elements and explained by the pattern of electron configurations and the presence of completely or partially filled shells (and subshells) of electrons in atoms.

The number of the principal energy level and the number of valence electrons in an atom can be deduced from its position on the periodic table.

Trends in first ionization energy across periods account for the existence of main energy levels and sub-levels in atoms.

The arrangement of elements in the periodic table helps to predict their electron configuration.

The quantized nature of energy transitions is related to the energy states of electrons in atoms and molecules.
Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Trends in atomic properties within the periodic table (periodicity) can be qualitatively understood through the position of the element in the periodic table, Coulomb's law, the shell model, and the concept of shielding/effective nuclear charge.

**NGSS: HS-PS1-1**

**AP: SAP-2.A.2**
Skills gain focus in AP and IB

- Science and Engineering Practices (NGSS), Science Practices (AP), and Applications and Skills (IB) are nearly identical in most respects.
- 8 SEP in NGSS, 6 SP in AP - Same skills, rearranged to reflect focus of the course.
  - NGSS SEP are general to science and engineering
  - AP SP are focused to Chemistry
- In IB the Applications and Skills are listed for each subtopic and are generally specific to that subtopic.
  - Applications and Skills are also related to the various Assessment Objectives and Aims of Group 4 (Experimental Sciences)
Skills gain focus

- **NGSS SEP 2 (Developing and Using Models)**
  - Use a model to predict relationships between systems or between components of a system

- **AP SP 4 (Model Analysis)**
  - 4.A Explain chemical properties or phenomena (e.g., of atoms or molecules) using given chemical theories, models, and representations.

- **IB Subtopic 3.2 (Periodic Trends)**
  - Prediction and explanation of the metallic and non-metallic behaviour of an element based on its position in the periodic table
  - Discussion of the similarities and differences in the properties of elements in the same group...
Themes are combined and connected

- Themes are overarching concepts, that when understood, become a problem solving tool.
- Are the most closely related between the three curricula.
  - **IB**: more generally and holistically supported
  - **NGSS**: Cross Cutting Concepts
    - Patterns
    - Cause and Effect
    - Scale, Proportion, and Quantity
    - Systems and System Models
    - Energy and Matter
    - Structure and Function
    - Stability and Change
  - **AP**: Big Ideas
    - Scale, Proportion, and Quantity
    - Structure and Properties
    - Transformations
    - Energy
Themes and combined and connected

- **NGSS CCC1 (Patterns)**
  - CCC1: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
  - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

- **AP BI 2 (Structure and Properties)**
  - SAP: Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.
  - SAP-2: The periodic table shows patterns in electronic structure and trends in atomic properties.

- **IB Nature of Science (Patterns)**
  - T 3.2: Looking for patterns—the position of an element in the periodic table allows scientists to make accurate predictions of its physical and chemical properties. This gives scientists the ability to synthesize new substances based on the expected reactivity of elements.

- **IB Theory of Knowledge**
  - T 3.2: The Periodic Table is an excellent example of classification in science. How does classification and categorization help and hinder the pursuit of knowledge?
Focus on Skills, Themes, and Content EQUALLY

- Less content to cover in NGSS
- HOWEVER equal focus is given to Science and Engineering Practices and Cross Cutting Concepts.
- You can extend content for all or subgroups of students
  - Don't let it affect the grade, especially if you are Standards Based Grading.
Focus on Skills, Themes, and Content EQUALLY

- Focusing Explicitly on SEP and CCC in On-Level Chemistry will grow and strengthen those skills for AP/IB and Beyond.
- Don’t be afraid to step away from the SEP/CCC identified in the standard. Many will likely apply just as easily
- When assessing, stick to the identified SEP and CCC in the performance expectation
Phenomenon Driven, not Activity Driven

- Traditional teaching is Activity focused.
- “Lessons should be structured so that the work is driven by questions arising from phenomenon, rather than topics sequentially pursued according to the traditional breakdown of lessons” - Reiser, 2013
- Phenomenon = any observable event that occurs in a natural or a designed system.
- Activity - Properties of Acids and Bases
  - Only really applicable in Gen Chem
- Phenomenon - Colors of Flowers
  - Gen Chem - properties of A&B, pH
  - AP/IBHL - structure, weak acids, indicators, absorbance
  - 3-5 - Identify materials based on properties
  - K-2 - classification of matter based on properties
When I adopted NGSS, 2015 - Year 1

- After thorough evaluation and with support of both admin and entire department
  - AP only school - simplified things a bit
- Attended workshops with Tom Corcoran, Paul Anderson, and early adopters at other schools BEFORE making decision.
- Introduced to all on-level courses simultaneously
- Teachers were given freedom to fail, and we all did
  - We were also extremely collaborative and supportive as a department
  - Shared successes and failures bi-weekly
- Students trusted us enough to give it a go
2016 - Year 2

- I hand-picked my AP students
- No real change in AP classes
  - Students had only had 1 partial year of NGSS instruction and teachers were still learning.
  - High Content knowledge
  - Poor lab skills
  - Poor application of ideas
- Saw good progress in On-level Chem
  - Students had NGSS Bio the previous year, and were starting to make the changes necessary
2017 - Year 3

● AP Students this year came from 2 years of NGSS instruction.
  ○ Content knowledge was definitely lower than previous
  ○ Lab skills were noticeably better
  ○ Ability to problem solve and apply ideas in new situations was markedly better

● Similar improvement in on-level Chemistry
  ○ Students were carrying over skills from Biology and Middle School much more effectively
Sources

- College Board. *AP Chemistry Course and Exam Description.* College Board, 2019.
Questions?
Survey, Certificate, and Downloads

To complete a brief survey about this webinar, and to generate your certificate of attendance, visit:

To Download Resources:

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