Efficient and Effective Strategies to Assess Secondary Science Labs Across All Levels

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Father Lacombe High School
(Science 24, Science 10 (AP), Biology (AP)

Link to Google Drive for Labs

Topics to discuss

- How to create labs with assessment in mind, to:
  - Reduce teacher workload
  - Improve student lab skills and understanding

- Differentiate assessment based on course level
  - Science 24
  - Science 10
  - Biology 20
  - Biology 35AP

Link to Google Drive for Labs

Science 24

Labs are designed with the following in mind:

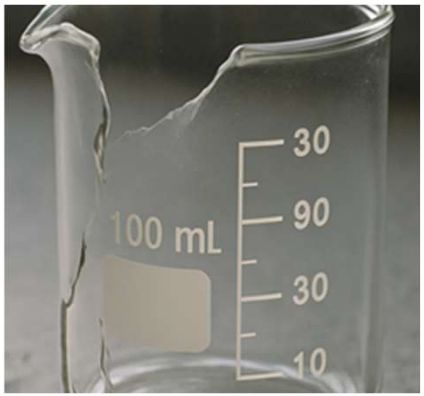
Challenges:

- Limited lab skills
- Difficulty reading
- Behavior
- Attendance

Strengths:

- Tend to be more confident to “try things”
- Often bring hands on skills from foods / trades

Sci 24 Challenge: Limited lab skills



- Materials and equipment –use plastic instead of glass (less breakage), measuring spoons instead of scales
- Groups work step by step with the teacher guiding each step
- Emphasize lab skills, learning the names of science equipment, observation skills, vocabulary, and FUN!

Sci 24 Challenge: Difficulty Reading (due to language and learning disabilities)

- Lab sheets are “self-contained”, including relevant background information
- Background is read together as a class and discussed prior to the lab
- Instructions are written in simpler language
- Analysis is very short and basic

Science 24 Chemistry Lab: Making Plastic Out of Milk

Overview: In the 1900's, milk was commonly used to make everyday items such as buttons, hair combs, and even jewelry. In this lab, you'll be conducting your very own chemistry experiment by making **casein plastic** from milk.

Background: How does milk make plastic?

To answer that we need to think first about what plastic is. The word plastic is used to describe a material that can be moulded into many shapes.

Sci 24 Challenge: Behavior
Solution: Scientific Approach **for Marks**

This is the “Attitudes” section of the Science 14/24 Program of Studies

1. Interest in Science
2. Mutual Respect
3. Scientific Inquiry
4. Collaboration
5. Stewardship
6. Safety

- 10% of their grade (equally divided per attitude)
- Continuously assessed during all activities and labs, included in gradebook as Pass/Fail

Scientific Approach

Name: _____

Start Date: _____ End Date: _____

1. **Interest in Science: enthusiasm and continuing interest in science**

   ☐

2. **Mutual Respect:**

   ☐

3. **Scientific Inquiry: active inquiry, problem solving and decision making.**

   ☐

4. **Collaboration:**

   ☐

5. **Stewardship: responsibility in science applications for nature and society**

   ☐

6. **Safety**

   ☐

Teacher Checklist Version

First Name	Interest in Science	Mutual Respect	Scientific Inquiry	Collaboration	Stewardship	Safety	First Name

Sci 24 Challenge: Attendance

- Strict lab attendance policy: unexcused absences result in a 0, no opportunity to redo the lab. Excused absences are “excused”.

- Students with long absences (including UNK) can be excused if they improve attendance (teacher judgement!)

Creating labs with these challenges in mind is helpful for **all levels of science!**

Science 24 Lab Assessment

- Attitude checklist while they are working
  - Teacher or student copy
- Circulate to ensure procedures are being followed and check observations
- Clean-up checks (for marks)
- Collect group lab sheets, mark analysis questions

Science 10 Labs

- More lab skills required – using a scale properly instead of using measuring spoons
- Rubrics or brief analysis sections, individually completed
- Strategy to reduce marking load if needed: spot marking

- No scientific attitude marks
- Clean up check marks, safety infraction deductions

Safety Infractions

Clean-up Check

Science 24 vs Science 10 Versions of Energy Change Lab

Science 24 uses plastic bags and touch to detect temperature change.

Measuring spoons instead of scale

Procedure

1. Obtain 3 plastic zipper bags and label each bag with a letter (A, B, and C).
2. Measure 1 teaspoon of Chemical A (in the beaker labelled "A") into the plastic bag labelled "A".
3. Measure 20 mL of distilled water from the water bottle using the graduated cylinder.
4. Carefully pour the water into plastic bag "A".
5. Gently press out excess air from the bag and seal the bag.
6. Gently swish the bag to mix the contents.
7. Record observations in the observations table.
8. Once the reaction is complete, empty the plastic bag contents into the waste beaker and throw out the plastic bag.
9. Repeat the procedure with Chemical B and Chemical C.

Science 24 vs Science 10 Versions of Energy Change Lab

Science 10 uses beakers, scales, and thermometers

Procedure

1. Record the name and chemical formula of the chemical that is in the beaker next to the scale at your starting station's scale.
2. Measure 5.00 g of the chemical found at the scale station (calcium chloride, sodium chloride, or ammonium chloride) using the scoopula or plastic spoon and a weigh boat.
3. Bring the weigh boat to your work station.
4. Pour 20 mL of distilled water from the water bottle into the 50 mL beaker. Note that the precision of the 50 mL beaker is approximately +/- 2 mL.
5. Take the thermometer out of its plastic case.
6. Measure the initial temperature of the water in the beaker, record in the observations table.
7. Gently place the thermometer on a paper towel on the lab bench **(do not leave it in the beaker).**
8. Carefully pour the powder from the weigh boat into the beaker with water.
9. Gently stir the solution using the glass stir rod (**do not use the thermometer to stir!)** until the powder has completely dissolved.
10. Record final temperature of the solution.

Science 24 vs Science 10 Versions of Energy Change Lab

Data Tables:

Science 24

Observations

	Chemical A	Chemical B	Chemical C
What did you see? What did you feel?			

Science 10

Data

Chemical: _____

	Temp (°C)
Initial (T_I)	
Final (T_F)	
Change $\Delta T = T_F - T_I$	

Other observations:

Chemical: _____

	Temp (°C)
Initial (T_I)	
Final (T_F)	
Change $\Delta T = T_F - T_I$	

Other observations:

Chemical: _____

	Temp (°C)
Initial (T_I)	
Final (T_F)	
Change $\Delta T = T_F - T_I$	

Other observations:

Science 24 vs Science 10 Versions of Energy Change Lab

Science 24 Analysis Questions:

1. Table salt – NaCl (s) dissolves when added to water but does not result in a chemical reaction. Which chemical was table salt (A, B, or C)? Explain.

2. Ammonium chloride – NH4Cl (s) reacts with water in an endothermic reaction. Which chemical was ammonium chloride (A, B, or C)? Explain.

3. Calcium chloride – CaCl2 (s) reacts with water in an exothermic reaction. Which chemical was calcium chloride (A, B, or C)? Explain.

Science 24 vs Science 10 Versions of Energy Change Lab

Science 10 Analysis Questions:

1. Which of the three chemicals did not react with water? Explain.

2. Which of the chemicals reacted with water in an endothermic reaction? Explain.

3. Which of the chemicals reacted with water in an exothermic reaction? Explain

Science 24 vs Science 10 Versions of Energy Change Lab

Science 24 Analysis Questions:

4. Brainstorm one useful application for the endothermic reaction in a bag. What could this be used for in the real world?

5. Brainstorm one useful application for the exothermic reaction in a bag. What could this be used for in the real world?

Science 24 vs Science 10 Versions of Energy Change Lab

Science 10 Analysis Questions:

4. The chemicals reacting with water that were exothermic and endothermic (Q2 and 3) are examples of double replacement chemical reactions.

Write out the balanced chemical equation (including states) for these two reactions.

(Hint: write water as HOH(l) because it will dissociate into H+ and OH- ions during a double replacement reaction.)

Biology 20 Labs

Problem:

Students mindlessly copy results and analysis responses from their peers (or AI), not understanding the lab

Teachers spend a huge amount of time marking these low effort, low quality submissions

Solution: Biology 20 Lab Exams

- Short lab exams are given 1 week after each lab
- Open book: students can access only their lab sheet while they complete the lab exam
- Lab sheets may be collected with the lab exam
- Students absent on lab day complete a lab sheet using data from their peers, then take the lab exam

Biology 20 Lab Exams

- Questions come directly from the lab sheet
- Distractors are based on common misconceptions (found marking the labs previously)
- MC and NR for ease of marking

Use the following information to answer the next three questions

Properties of Common Leaf Pigments

Pigment	Colour	Relative Solubility
Chlorophyll A	Bright green to blue-green	Medium
Chlorophyll B	Yellow-green to brown-green	Medium-low
Carotene	Orange-yellow	High
Xanthophyll	Light yellow	Medium-high
Anthocyanin	Reddish-brown	Not soluble

Observations Table for Student A

Pigment	Colour	Distance pigment travelled from load line
Pigment 1	Yellow	15 mm
Pigment 2	Yellow	18 mm
Pigment 3	Green	10 mm
Pigment 4	Green	7 mm

Distance travelled by solvent = 20 mm

Super straight-forward questions

Testing analysis skills using mock data

1. What is the identity of pigment 3?

A. Chlorophyll A **B.** Chlorophyll B **C.** Carotene **D.** Xanthophyll

2. In what order did the pigments appear on Student A's chromatography paper?

A. Solvent Line, Pigment 1, Pigment 2, Pigment 3, Pigment 4, Load Line
B. Load Line, Pigment 4, Pigment 3, Pigment 1, Pigment 2, Solvent Line
C. Load Line, Pigment 2, Pigment 1, Pigment 3, Pigment 4, Solvent Line
D. Solvent Line, Pigment 4, Pigment 3, Pigment 1, Pigment 2, Load Line

Numeric Response

1. Determine the Rf value of Pigment 4.

Record your numerical-response answer as a decimal rounded to two decimal places.

A question students always got wrong when I marked their lab reports

6. Fill in the following statements:

Pigments with higher solubility have a _____ Rf value.
(lower/higher)

Pigments with lower solubility have a _____ Rf value.
(lower/higher)

Corresponding question on the lab exam:

3. What is the relationship between solubility, distance travelled, and Rf value?

A. Higher solubility = higher distance travelled = higher Rf value
B. Higher solubility = lower distance travelled = lower Rf value
C. Lower solubility = higher distance travelled = lower Rf value
D. Lower solubility = lower distance travelled = higher Rf value

My students typically struggle to answer these questions on the lab report:

8. Identify one **human error** that may have affected your results. Human error is something that you (the human) may have done incorrectly.

9. Identify one experimental error that may have affected your results. Experimental errors are problems with the design of the lab procedure and/or materials. **Do not describe another human error.**

Corresponding question on the lab exam:

4. Which of the following is an experimental error of the chromatography lab?

A. After removing the chromatography paper from the beaker, allowing the solvent to dry before marking the pigment and solvent lines
B. Transferring oil from fingers onto the middle of the chromatography paper
C. Not wearing gloves when handling the chromatography paper
D. Hanging the chromatography paper so that it touches the sides of the beaker

Biology AP Labs

- More statistics, graphing and calculations compared to regular biology labs

- **Peer review**
- Reviewers are graded on how well they catch mistakes
- Students are given the opportunity to fix their mistakes
- Can take off marks if reviewer missed mistakes

Skills labs: Dilution Checkpoint Lab

Chemistry Lab Skills: Dilution

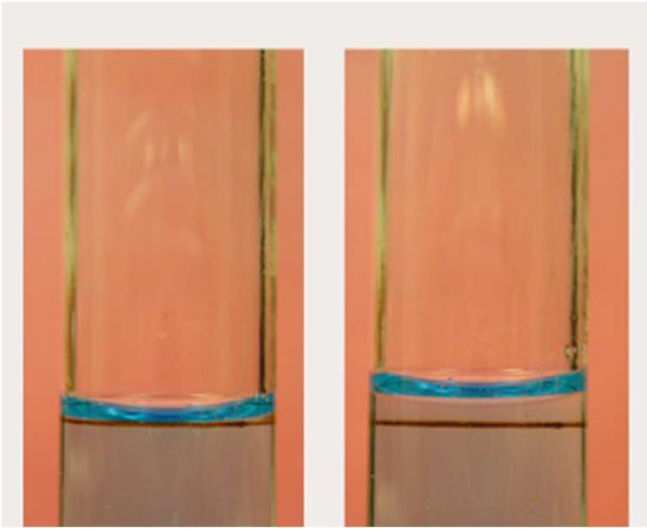
Part A: Making a Standard Solution

1. Measure ____ g of solute using a digital scale, place into a small beaker.

   Teacher Check _____

2. Dissolve the solute in the beaker with as little distilled water as possible.
3. Carefully transfer the dissolved solute into a volumetric flask.
4. Rinse your beaker with a small amount of distilled water, add to the volumetric flask.
5. Carefully fill the volumetric flask with distilled water until the **top** of the meniscus almost touches the 100 mL line.
6. Using an eye dropper, add distilled water drop by drop until the **bottom of the meniscus** touches the 100 mL line (pictured below). If you accidentally add too much water, you must discard the solution and start over.
7. Stopper the volumetric flask. Firmly hold the stopper in place and invert the flask 15 times to mix the solution. This solution will be used for Part B of the lab.

   Teacher check: _____



Q&A, Discussion Time

Link to Google Drive for Labs

Questions? Contact **nicole.zanewick@cssd.ab.ca**