FUNDATORY EXPERIMENTS MADE RELEVANT:

HOW TO IMPLEMENT A SIMPLE BUT EFFECTIVE LEARNING STRATEGY IN THE CHEMISTRY CLASSROOM

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The Idea

- At present the Irish second level science syllabi comprise a number of so-called **mandatory** experiments.
- Mandatory is a compelling word, invoking box-ticking and compliance.
- **Fundatory** is a **hybrid** of *fun* and *mandatory*, *to invoke creativity and fun* in the required mandatory tasks.

So,

Fundatory Experiments Made Relevant

is where the **fun** is mandatory and the experience **relevant**

- In my classes I have found that students were more involved and engaged in their own learning when participating in a **challenge** that is presented in a **fun** and **relevant** way.

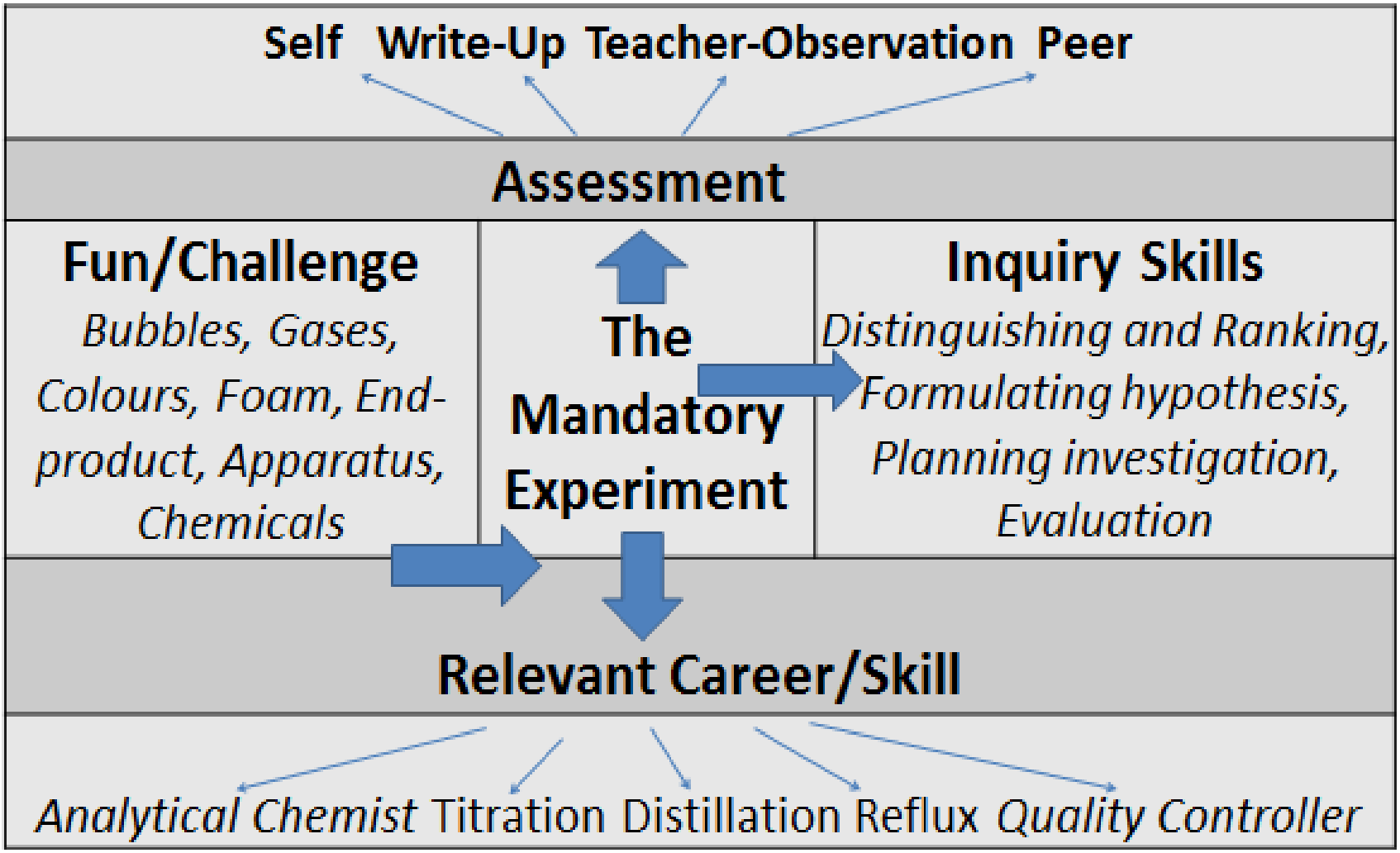
- By presenting the mandatory JC and LC chemistry experiments in a **fun** and **relevant** way, students engage more readily and will use the skills of inquiry *naturally*, to achieve the task.

- This task or challenge can be associated with the *job of a working chemist* or simply a *laboratory skill* or *technique* presented in an inquiry format.
- Students *will complete a required mandatory experiment*
  - while *additionally engaging in a related challenge*, which will involve using ***inquiry skills*** and assessment of their own learning and achievement.

- At the end of the challenge, a **winning team** will be identified as the group *who problem solves best*, given clearly defined expectations.
- Most students respond to a challenge, readily using inquiry skills, especially when up against each other, and a *token prize* is involved.
- I have found this approach to teaching and learning *benefits the weaker students* as well as *fully engaging the more academic*.

By changing the way mandatory experiments are presented opens up the opportunity for teachers to **use their creativity**, to make the learning experience richer and more appealing for all involved.

The table below represents a *model* of this learning strategy



My experience

- I have used this learning strategy **with 6th year LC chemistry students** *who have basic lab skills from experiments covered at JC science and their 5th year chemistry course.*
- *The students were all girls, aged 17-18 years.*
- *Most were high achievers, aiming for over 500 points in the LC exam.*

My Motivation

(for using an inquiry based learning strategy, with an academic, exam group!)

I used the learning strategy for the following reasons;

- to help them be **more focussed** during mandatory experiments
- to improve **learning and understanding** of related topics
- to **revise** key techniques of experiment procedures in a fun and focussed way
- to develop good **group communication skills**
- to develop good **time management skills**
- to develop **analytical skills**
- to develop **inquiry skills**

It was worth the risk, for the following reasons;

I observed that students were;

- more engaged in their work
- communicating more with each other
- helping each other out with parts of the experiment/challenge
- sharing knowledge freely within their groups
- wanting to know more about the experiment, the how/why

To date, I used this learning model for a number of the mandatory experiments on the LC chemistry course, mainly *titration type experiments* and each time I observed the same focus and engagement in the challenge that was set.

- I believe that the students responded positively to the idea that they could *play* at being ‘chemists’ for the class and proudly took on the title and challenge.
- The lab skills and math calculations, where needed, had all been done before, in at least one other mandatory experiment, so students *did not feel overwhelmed* by the challenge.

- They all enjoyed the ‘competition’ aspect.
- I had a **prize** for the winning group each time.
- The **title** of ‘Titration Queens’ or equivalent, also generated additional interest and focus within groups and became a *coveted award*.

- The students requested this ‘challenge’ format be used for their remaining experiments.
- I found these ‘challenge’ classes more engaging and enjoyable myself and that they allowed greater opportunity for extended learning to take place.
- The classes were very student-focussed and mainly ‘hands-off’ by the teacher.

- I observed that students were using *scientific language* to explain their results.

- I observed that *linked topics* were discussed *e.g. stoichiometry, students now understood what p.p.m. meant and its equivalent unit mg/L.*

I informally assessed the students throughout the challenge by;

- **observing** each group/individual as they carried out the experiment
- **compared** each group as they worked
- **listening** to their discussions
- **evaluating** their results and conclusions

A Sample Lesson Plan I

One of the LC mandatory experiments is selected.

It is worded as follows;

To prepare a sample of Soap

A very detailed description of how to carry out this experiment is available in many formats.

Prior Knowledge/Pre-requisite skills

Students *will have;*

- carried out basic refluxing and distillation lab techniques and
- understand some types of chemical reactions in organic chemistry.

The challenge

By presenting the experiment in the following *novel way;*

A well-known pharmaceutical company is advertising for a person with a chemistry background, specifically on ***how to make soap****, to help launch a new cosmetic range of products.*

Using your **prior knowledge** and **details provided by the mandatory experiment**, consider the following;

- ***What are the essential features of a marketable soap and how would you test for these features?***
- Using the criteria decided on by the class, a '**Most marketable Soap Award**' will be presented at the end of the session.

Each group will;

- *Discuss/describe features of a marketable soap*
- *Come up with a **suitable method to test soap** for these features.*
- *Collaborate with the class to determine test(s) for the soap.*

- ***Prepare a sample of soap*** *according to the mandatory chemistry experiment description.*
- *The 'Most marketable Soap'* ***will be determined, by tests previously decided by the class****.*
- *Experiment* ***write ups*** *must include the* ***test results*** *for the group's soap, and* ***a report*** *on how the group might improve their soap, if they repeated the experiment.*

Inquiry features

Students will complete a mandatory experiment ***while engaging in the challenge to decide the essential features of a marketable soap and how to test these features***.

**A possible worksheet, with a test to determine the most marketable soap, is available as a backup.*

Assessment opportunities

All of the following methods will be used to assess students learning and use of inquiry skills.

- *Teacher-Observation*
- *Write-ups*
- *Self-Assessment*
- *Peer-Assessment*

- Students will attempt to **problem-solve** using *inquiry skills* throughout the session, analysing, reflecting and refining their own work and the groups, **to produce individual write-ups** and a **group report**.
- From **observing** and circulating, the teacher will guide and facilitate the inquiry process **verbally**, throughout the session.
- This can be followed up with a **written report** for the students and the teachers own records, for future reference.

An suggested *assessment rubric*

Inquiry Skills	***Not Evident***	***Developing***	***Established***	***Extension/Improvement***
Problem solving	Student(s) need help to recognise the problem and only participates in the solution.	Student(s) needs help to recognise the problem but can help with the solution.	Student(s) recognises the problem and gives ideas towards a solution	Student(s) make suggestions based on evidence with scientific reasoning towards improving the experiment outcome.
Critical thinking	Student(s) cannot distinguish between suitable/unsuitable solutions and cannot express supportive arguments for or against.	Student(s) can distinguish between some suitable/unsuitable solutions but unsure about expressing supportive arguments for or against.	Student(s) can distinguish between suitable/unsuitable solutions and express supportive arguments for and against.	Student(s) can reflect and refine their ideas at each stage of the process.
Planning investigation	Student(s) can follow the prescribed steps only, with help, to carry out the investigation, but will struggle with time management.	Student(s) can follow prescribed and un-prescribed steps, with help, to carry out the investigation, but will struggle with time management.	Student(s) can follow prescribed and unprescribed steps, to carry out the investigation, within the time constraint.	Student(s) will use evidence from their findings to inform possible sources of error, for future experimenting.
Collaboration, communication	Student(s) show a lack of coordination and little ability to delegate and cooperate throughout the task.	Student(s) show some ability to delegate and a willingness to cooperate with the group throughout the task.	Student(s) show organisation skills and ability to delegate and cooperate with the group, throughout the task.	Student(s) take responsibility for their specific tasks, giving a progress report throughout and takes initiative to challenge and change events.

*A possible worksheet/test to determine the most marketable soap

Most marketable soap test sheet

Lather test

1. Place 1g of soap in 20 mls of water in a boiling tube.
2. Shake for 10 seconds and leave to stand for 30 seconds.
3. Measure the height of bubbles only, in the boiling tube in cm and record.

pH reading test

- Using the soap solution from the lather test, dip with universal indicator paper and record pH reading from colour chart. *Alternatively, use a pH meter reader.*

Results	
Lather test (cm)	
pH reading test	

A sample lesson plan II

The LC mandatory experiment

To determine the amount of iron in an iron tablet is selected

Prior Knowledge/Pre-requisite skills

- Students will have carried out *basic titrations* and understand what a *standard solution* is.

The challenge

This experiment can be presented in the following *novel way* to a class of LC chemistry*;*

*A **Quality Controller** position has been advertised in a local laboratory.*

Ask the students to discuss

- *what are the duties of a quality controller and*
- *how might they apply to this mandatory experiment.*

Students will carry out the following tasks;

- **Determine the amount of iron in an iron tablet using titration against a standardised solution.**

The related Inquiry challenge:

- As a quality controller consider, **how would you get *a more accurate value* for the amount of iron in one iron tablet, if you were to re-do the experiment?**
  - Start by determining your ***percentage error*** based on actual and experimental amounts.
  - Consider what were the possible sources of error in your final value for the amount of iron in one tablet? Give 3 *possible sources of error* in your answer.
- **Repeat** the experiment, *based on your quality control review.*

The winning teams will be;

- the team to get **the closest iron value in mg/per tablet**, **stated on the pack**, *initially* and
- the team **to most improve their percentage error**, following their *quality control review* repeat experiment.

Inquiry features

The students will consider **how would you get *a more accurate value*** **for the amount of iron in a tablet** by carrying out **quality control** on their own experimental procedure, as follows;

- calculate their percentage error
- Identify possible sources of error
- Repeat the experiment to try improve the percentage error

Assessment

A similar approach to assessment is used as in the **previous example**;

- Assessment opportunities will include
  - *Teacher-Observation, Write-ups, Self-Assessment, Peer-Assessment.*
- An assessment rubric will cover the inquiry skills
  - Problem-solving, Critical thinking, Planning investigations, Collaboration and communication

  where a scale of achievement is identified

Conclusion

- This learning strategy can be applied to as many of the JC and LC mandatory experiments *as are suitable.*
- Being *creative* about the way the related challenge is presented is a significant factor in the success of this learning strategy and can be adapted to suit each schools individual environment.
- All aspects of the learning strategy can be adapted to suit each schools individual environment.

- The ideas used in the *sample lesson plans* above are mine and are only suggestions.
- The success is if your students *want to do it again*, to try *win* the next time!
- The learning experience is *more than you can assess!*

The End