Do Students perform in an Inquiry Based Learning Approach as assessed by a Formative Assessment to Inquiry approach in a Chemistry Laboratory task involving Chemical Change?

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Abstract

This work is directed towards enhancing student understanding of what it means to be a chemist in the laboratory in terms of, working safely with materials, displaying the dexterous capacity to carry out a laboratory investigation , working in a group, recording results, presenting results and interpreting the same results to develop a hypothesis. A 'hands-on', 'minds-on' inquiry based learning approach with Transition Year students (aged 15-16 years), in an Irish school setting was used over an eighty minute lesson. Not all students had a qualification in science education at junior school level (Junior Certificate Science). Students were free to select from available combinations of chemicals, mix and match them in zip-loc bags and observe the results. The household chemicals involved in all of the experiment are available in supermarkets. The chemistry involved includes acid-base, energy changes and iodiometric detection of starch. The 'Inquiry Based Learning Approach' experienced by students, where formal teacher instruction did not exceed four minutes, was coupled with a formative assessment to generate student performance indicators. Students exhibited competence in terms of their ability to perform the work of a chemist in terms of both the 'minds-on' and 'hands-on' aspects of the lesson. They also experienced fun and engaged well in their groups.

Introduction

Ireland is in the process of changing its Chemistry curriculum which will be aligned with new forms of both written and practical assessment. Senior cycle has largely undergone a significant phase of review. Following research and consultation with learners, teachers, management bodies, the development of more flexible programmes of learning, outcomes-based syllabi for subjects and short courses, the development of key skills and new ways of assessing will be developed. The NCCA (2012) highlight that assessment should change from its present format and that learners should engage in Inquiry (based learning) with an attendant change in focus on practicals, as currently undertaken. This experiment is adapted from another version (see Selco et. al 2011), in an attempt to embed these ideas in a chemistry laboratory learning setting.

Students in this lesson are in their first year of Senior Cycle and have completed the national Junior Certificate examination. It is a low-stakes, formative year which informs their decisions towards subject options for the remaining two years of this cycle. The Inquiry Based Learning nature of the lesson allows for a heuristic approach whereby students carry out 'hands-on' activites in the laboratory . They are asked to present their results and their observations, to help them ask a question or make a hypothesis regarding chemical change. The time restrictions of the lesson generally limit the various groups to a single hypothesis but this can vary.

An attempt to chart a learning pathway which might provide some reference points for assessment was undertaken by the teacher. This resulted in a competence model in terms of an assessment framework. It was useful to reflect on the complexity of the task within the framework in Figure 1 below so as to visualise an assessment context and anticipate the afore mentioned, 'reference points' for such a framework.

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Figure 1: Five Levels of Hierarchical Complexity for task development and analysis of Students' achievement in Chemistry (Bernholt et al. 2012)

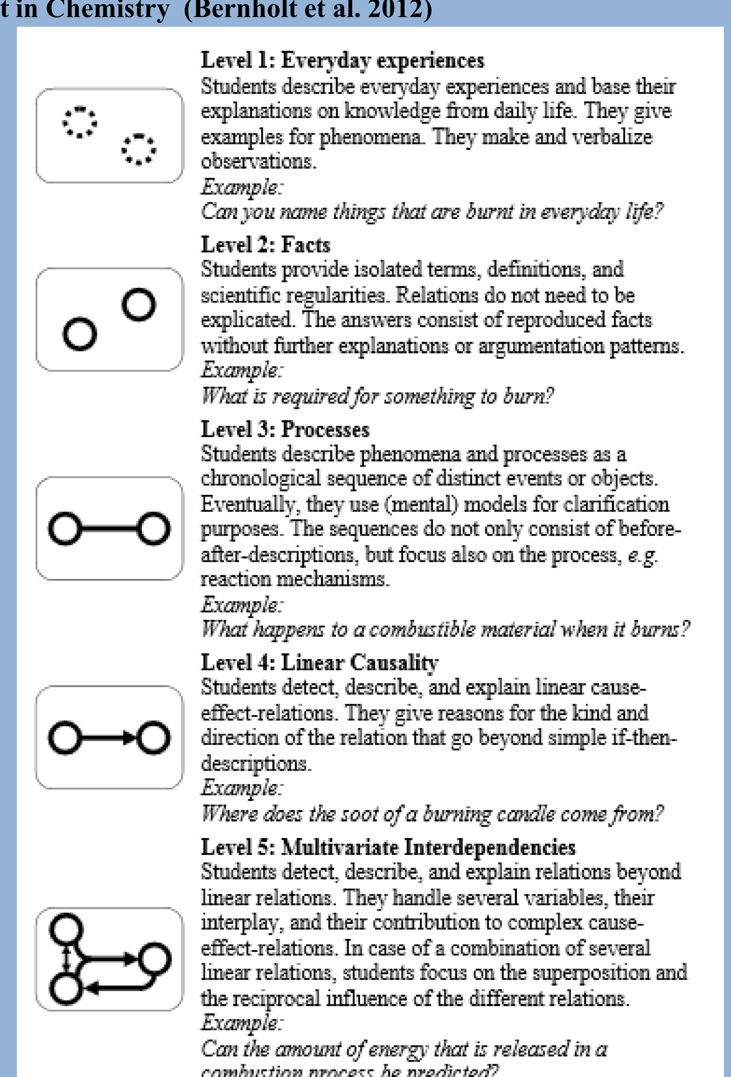


Figure 2:

Observing Chemical Change

Safety
Heat Changes, Safety goggles, lab-coat, disposable gloves

Equipment
Measuring Cylinder, disposable gloves, Ziploc bags, Plastic cups, Safety Goggles

Instructions

- Work in groups of two or three.
- Measure 15cm^3 of a liquid with a measuring cylinder and place it in a plastic cup.
- Place the cup upright in an open Ziploc bag.
- Place a spoon measure of two powders of your choice beside the plastic cup in the Ziploc bag. Do not allow any mixing.

- Squeeze all air out of the bag and zip.

- Mix the contents of the bag and record your observations.
- Record the number of the liquid and the letters of the two powders you usedd in the table below

Observations:

Liquid	Powder	Powder	Observations

Note: Observations may be things such as: colour change, a gas was produced, heat change occurred, texture change occurred

Be prepared to present your results so keep good records.

Given the results you obtained, develop a question or a testable idea that you have not yet tried out. What will happen if I combine two powders with any liquid e.g. Will I always get a cold temperature if I use these two powders and any liquid?

My Question or Testable Idea

____
____
____

Conclusion – Describe your findings and indicate if your idea was correct.

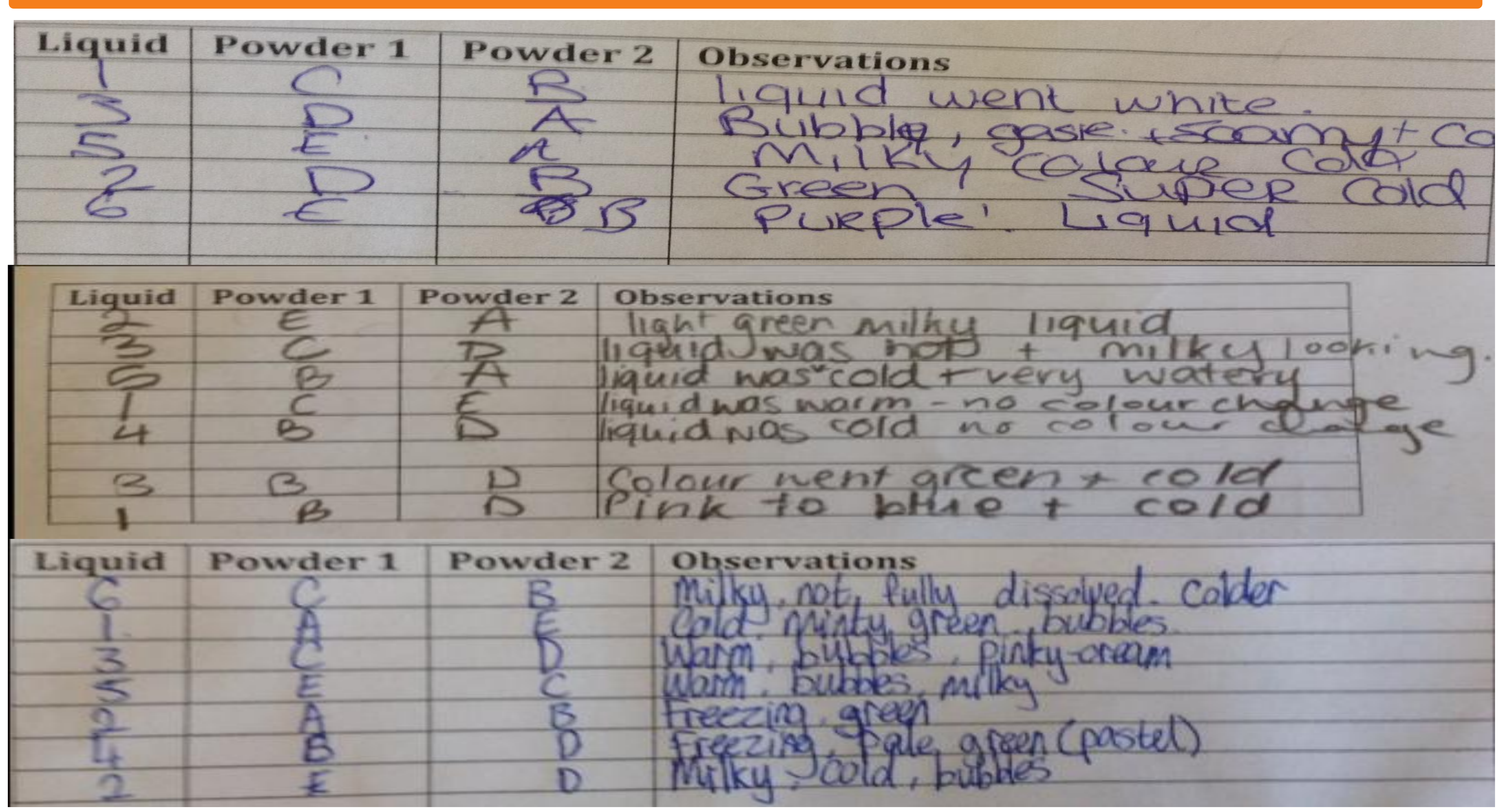
____
____
____
____

Complete the reflection on what you have learned during this class.
What I thought about Chemical Change at the beginning of the lesson:
____
What I have learned or think about it now:
____
What made me change my mind:
____
Extension: Try the exercises on the next page to see if you can figure out and identify the differences between chemical changes and physical changes.

Methodology

The materials used in this experiment included six powders labeled A → F and six liquids labeled I → VI. All chemicals were presented as shown in Figure. 2 and an instruction sheet was provided to each individual student to facilitate data recording (see also Figure. 2). This sheet could be modified to further challenge more senior students if deemed appropriate. Each group of two students performed eight different tests with randomly chosen sets of chemicals and recorded their observations into a table of results. During this time, students should have been noticing (potential) patterns of results develop and making inferences as to what powders or liquids are most likely to cause a certain type of chemical change. This forms the basis for their hypothesis. Some hypotheses are shown in the 'Result (Showing Hypotheses)' section.

Results (Showing Observations)

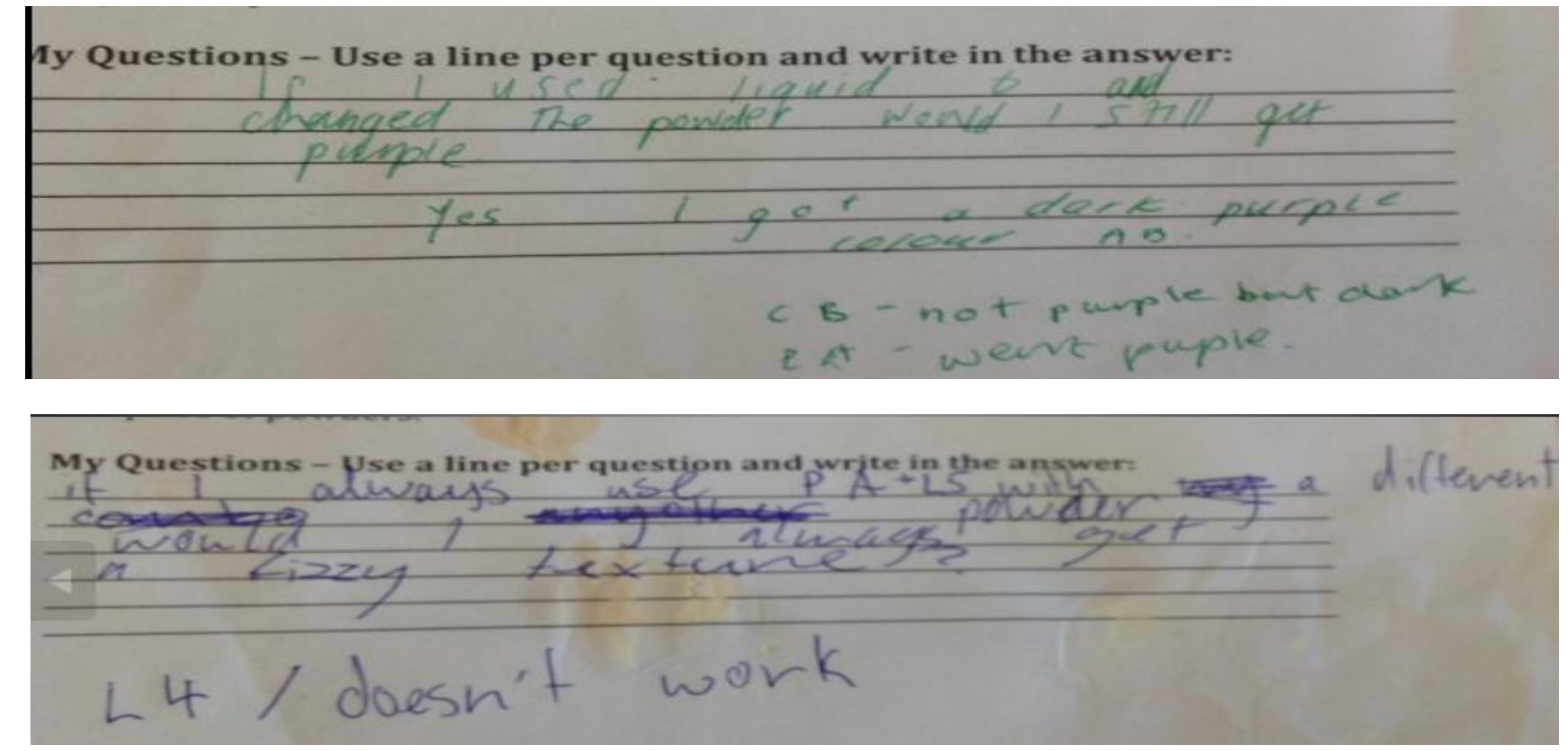


Liquid	Powder 1	Powder 2	Observations
1	C	B	liquid went white.
3	D	A	Bubble, gasie. + scomy + co
5	E	A	Milky colour cold
2	D	B	Green super cold
6	E	~~B~~ B	Purple! Liquid

Liquid	Powder 1	Powder 2	Observations
2	E	A	light green milky liquid
3	C	D	liquid was hot + milky looking.
5	B	A	liquid was cold + very watery
1	C	E	liquid was warm - no colour change
4	B	D	liquid was cold no colour change
3	B	D	Colour went green + cold
1	B	D	Pink to blue + cold

Liquid	Powder 1	Powder 2	Observations
6	C	B	Milky, not fully dissolved. Colder
1	A	E	Cold, minty green, bubbles.
3	C	D	Warm, bubbles, pinky-cream
5	E	C	Warm, bubbles, milky
2	A	B	Freezing, green
4	B	D	Freezing, pale green (pastel)
2	E	D	Milky, cold, bubbles

Results (Showing Hypotheses)



'Assessment of Competence' Model

Level	Carrying out Experiment	Recording Observations	Presentation of Results	Generating A Hypothesis
I	Conducts experiment in a chaotic fashion.	Partial / lack of recording	Partial Analysis given.	Vague question left unanswered (conclusion)
II	Adheres to safety measures. Conducts experiment in a fashion conducive to obtaining results.	Partial Recording and some qualitative descriptors	Partial analysis of results with reference to the aspect of chemical change to be used in hypothesis.	Clear question which is answered (conclusion)
III	Adheres to safety measures. Conducts experiment in a fashion conducive to obtaining results. Cleans the bench before arrival of the next class.	Fully documented results including qualitative descriptors such as heat change, texture change, colour change, production of gas.	Comprehensive analysis of results with reference to the aspect of chemical change to be used in hypothesis.	Clear question displaying inferences made which is well answered (conclusion).

Conclusion

Students completed the experimental activity with enthusiasm while engaging fully with the task and each other. All scored very well in the assessment and one point of note was one student whose previous academic record was unexceptional, out-performed all others in the assessment. The presentation gave students who were not inclined to speak publicly or not inclined to speak about science, an opportunity to gain confidence from showing their observations to their peers. Also of note, was the proclamation of a student who had not undertaken Science as a subject in the Junior Certificate, that she was committing to the Leaving Certificate Chemistry programme, the following year. Thus the objectives that the class would undertake a 'hands-on', 'heads-on experiment, developed into a 'hearts-on' experience for some and was thoroughly enjoyed by all. The phrase, 'I think' was used by students on a remarkable number of occasions throughout the lesson . The teacher instruction during the lesson did not exceed four minutes. The opportunity to be a real chemist and take ownership of their work, was evidenced by students recalling accurate details of the investigation some weeks later.

References

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