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Using ACELL to explore fluctuating student perceptions of an acylation of ferrocene experiment

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Supplementary information

The following data on assessment criteria, and a detailed educational analysis using the ACELL framework, is presented here to permit the reader further context to discussions in the main body of the manuscript.

Assessment criteria

The students, as part of their experimental procedure, were provided with the following specific and general assessment criteria and report requirements:

i.) It is important that it is clear to the assessor that you understood the experiment and basic theory behind the reactions that you carried out. This can be shown adequately by discussing the significance of your results (including analysis of spectra), writing a mechanism for the reaction and addressing the questions asked in the manual.

ii.) Accuracy of results as shown by visualisation of your products and TLC plates (remember to circle all spots in pencil as they will often fade before your reports are assessed), as well as yield, melting points and analysis of spectra generally reflect a degree of competency in mastering laboratory techniques and will therefore contribute to the assessment of this practical.

iii.) Clarity and layout of your report will also contribute to your assessment.

iv.) Experimental design is extremely important in the majority of science disciplines and it always begins with a 'theoretical' proposal. Results from the final part of this experiment (TLC analysis) are to be used for you to design an experimental procedure that will effectively isolate acetylferrocene from your crude acylation product. How well you achieve this will contribute to your assessment.

The students then prepared an experimental report, which was instructed to contain the following components:

- the flow sheets you have prepared (where requested)
- rough working pages
- the full experimental section, which should include the reagent table and a listing of all spectroscopic data either provided or recorded.
- answers to the questions

Finally, the report prepared was assessed on the basis of the following criteria:

a.) quality and yield of products,

b.) clarity of report - including neatness and legibility,

c.) answers to questions.

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Table S1 ACELL educational analysis of this experiment

Learning Outcomes What will students learn?	**Process** How will students learn it?	**Indicators** How will staff and students know that the students have achieved the learning outcomes?
Theoretical and conceptual knowledge		
The students will use material taught in lectures to explain how electrophilic aromatic substitution of aromatic molecules works.	By providing a mechanism for the reaction	During the experiment, interaction with a demonstrator will indicate that students are proceeding on the right path. Students are expected to provide a mechanism as part of in their submitted report. Staff/demonstrator would provide feedback on the mechanism provided.
The students will use material taught in lectures to assign the various spectra obtained/provided during the experiment.	They have to identify the relevant IR absorptions. They are asked to analyse the NMR spectra provided and assign any relevant peaks	During the experiment, interaction with a demonstrator will indicate that students are proceeding on the right path. The identification and assignment of absorptions/signals forms part of the report submitted for marking. Staff/demonstrator would provide feedback on the assignments made.
Scientific and practical skills		
Ability to observe and record, and report, using appropriate scientific language.	They are required to write up the experiment during the formal session. Their experimental observations, structural assignments and their conclusions form the basis of this report. This would take the form of an experimental section, plus analysis of data obtained and/or provided.	They will hand in the written-up work to the demonstrator. The demonstrator will mark the report and provide feedback on the quality of the work.
Experimentally, students will learn the procedure and aspects of chromatography (both thin-layer and column)	The student performs the experiment with occasional guidance provided by a demonstrator. When they observe the thin-layer chromatograms they will know, themselves, that they have mastered this technique.	The successful purification of acetylferrocene will be the indication that the students have mastered the necessary skills required of this experiment.
Ability to form hypotheses and test them experimentally	The student must determine a way of separating acetylferrocene from ferrocene. They try a range of different eluting solvents and based on their results, they must develop a procedure to achieve the separation on the sample they have prepared.	The student will obtain a pure sample of acetylferrocene.
Thinking skills		
The student will develop self-management skills as they must plan and organise a way to purify acetylferrocene.	The student must determine a way of separating acetylferrocene from ferrocene. They try a range of different eluting solvents and based on their results, they must develop a procedure to achieve the separation on the sample they have prepared.	Before the actual procedure is carried out, the student must discuss their plan with the demonstrator. Approval of the plan will indicate the successful application of skills. If the plan is not approved, the resulting discussion will help guide the student in their development of a new plan.
Generic skills		
Students will enhance effective communication by having to submit a written report.	Written communication skills will be developed as the report is prepared.	The required written report will evaluate this aspect.

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