

DEPARTMENT OF
CHEMISTRY



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Group-based Experimental Design in the First-Year Undergraduate Teaching Laboratory: An investigation into solvent polarity

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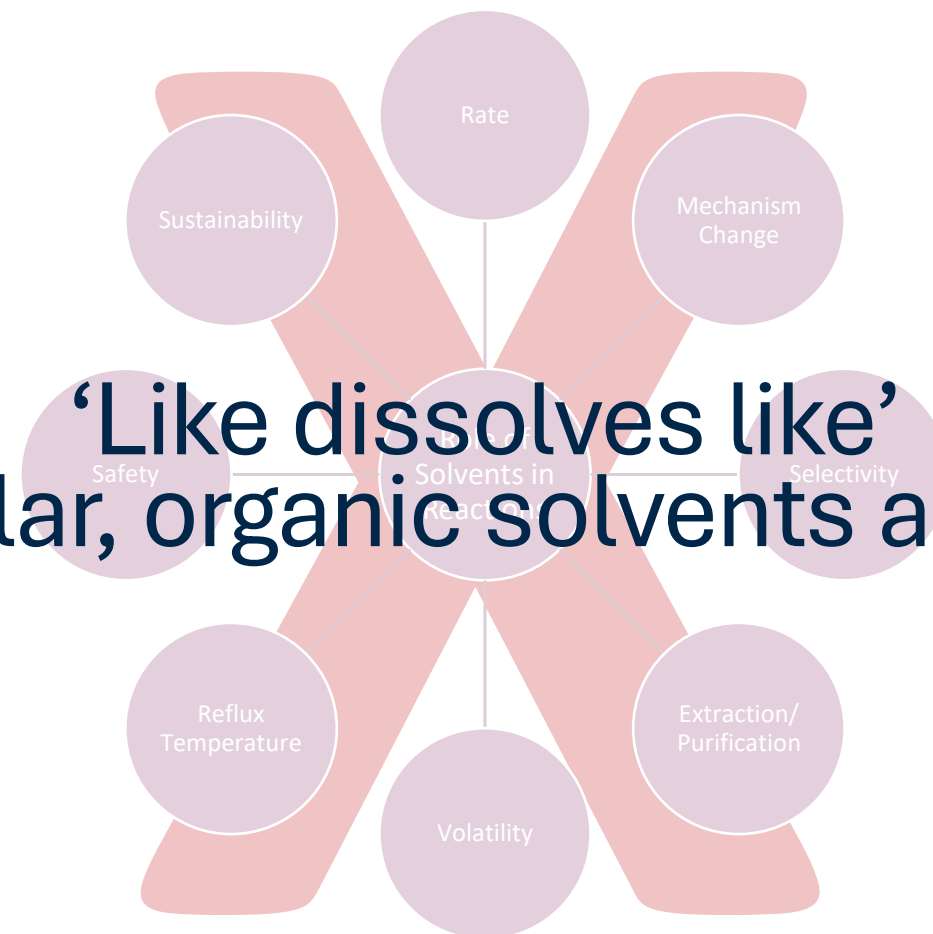
ViCE-PHEC 2025

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Wilmore, J.T., Forsyth, E., Campbell, C.D., Rowlands, L. J., Hancox, C.C. and Stewart, M.I.,
Manuscript submitted.

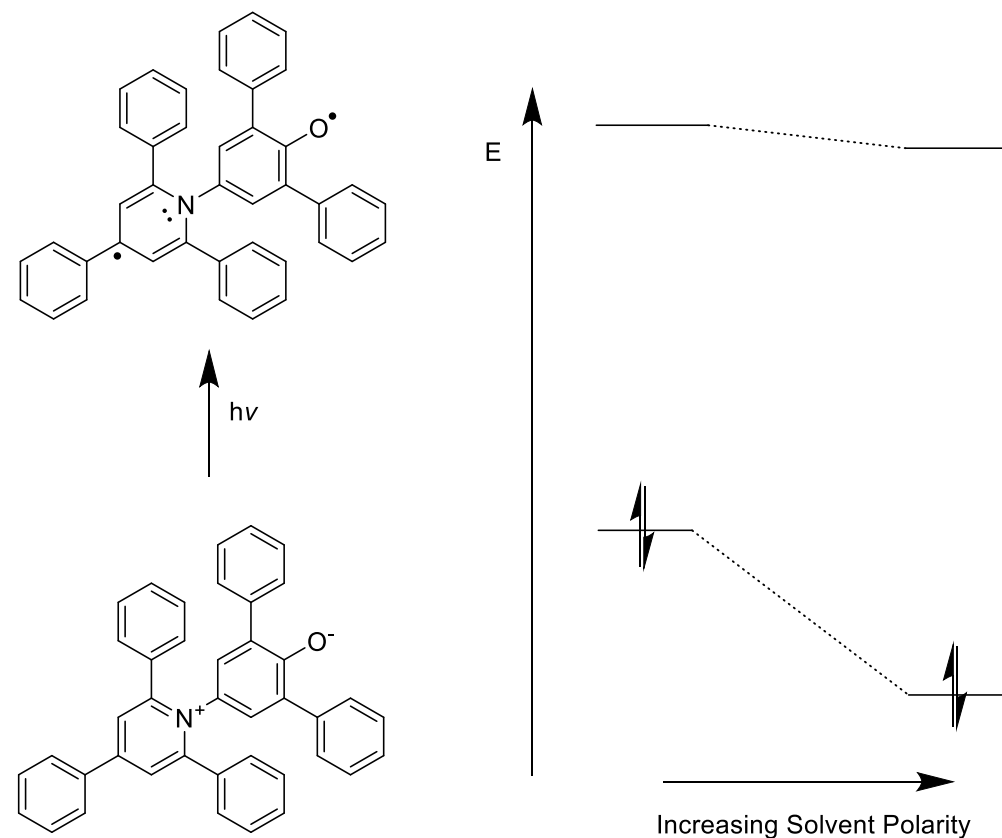
Role of Solvents in Reactions

‘Like dissolves like’
‘Water is polar, organic solvents are non-polar.’

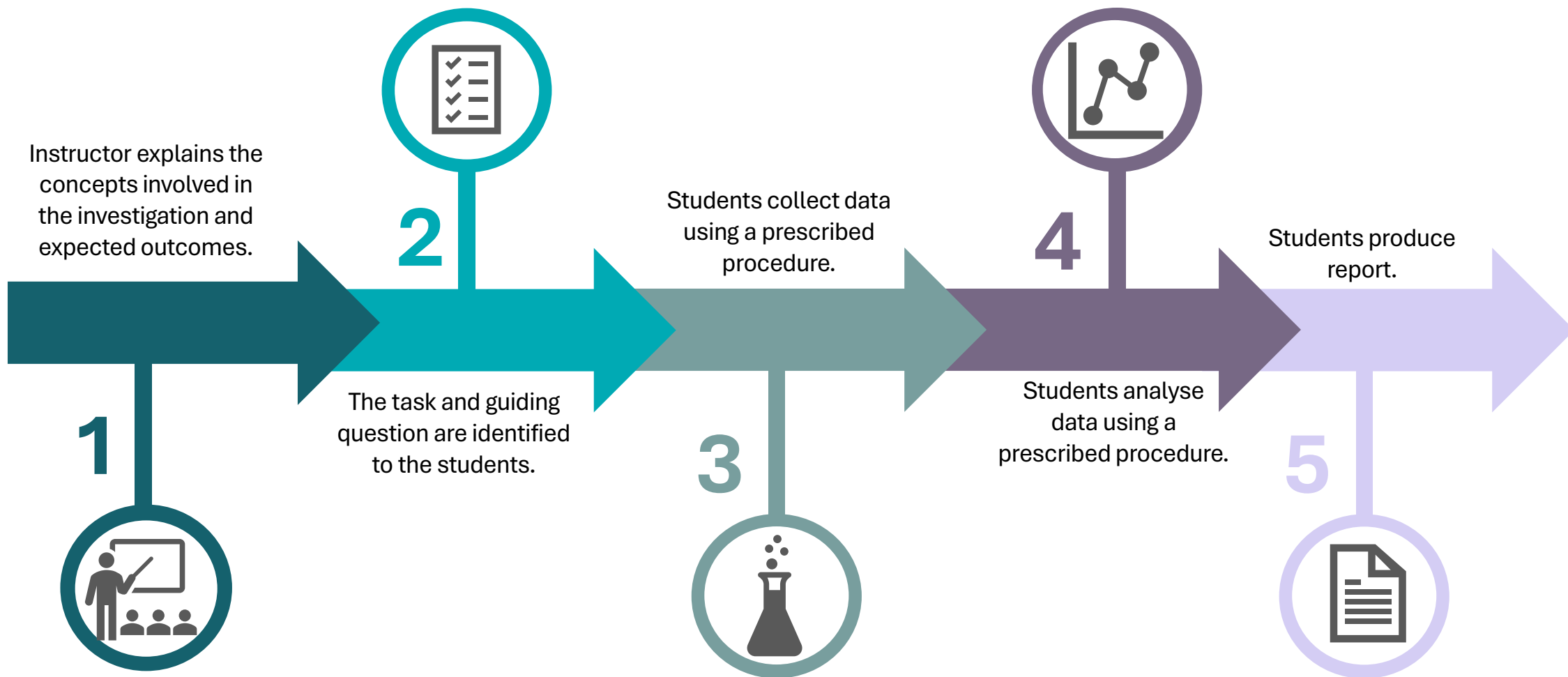


Solvatochromism and Reichardt's Dye

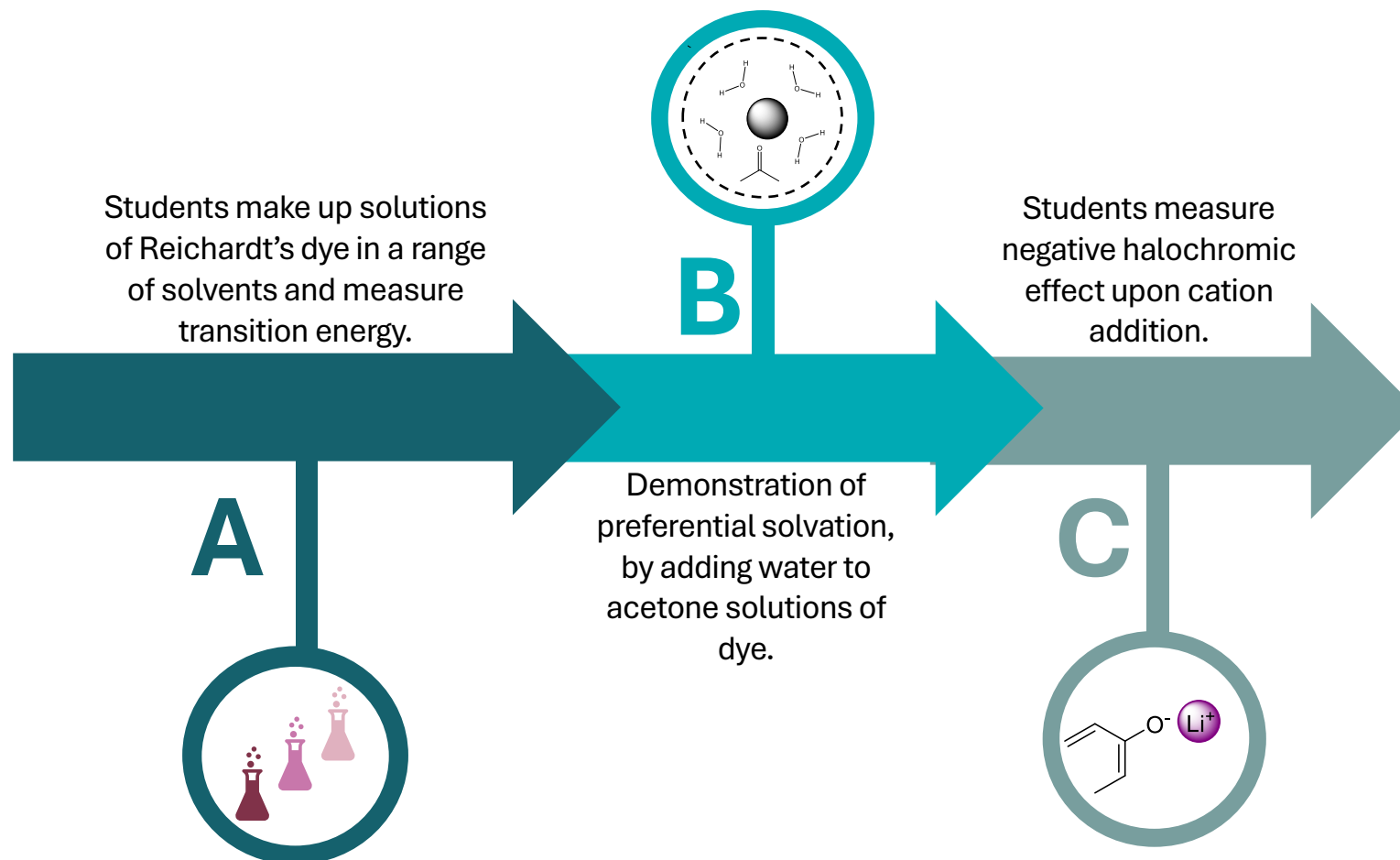
‘Obviously, solvent polarity thus defined cannot be described by a single physical solvent parameter [...] overall solvation capability depends on all possible - specific and non-specific intermolecular forces between solute and solvent’
-- Reichardt



Expository Practical



Previous Expository Practical



Expository Practical: Repetitive, to what end?

Student feedback:

“The practical felt very repetitive, with the same steps having to be carried out very many times to obtain absorbance data.”

“A lot of the measurements with the UV/Vis machine just felt repetitive.”

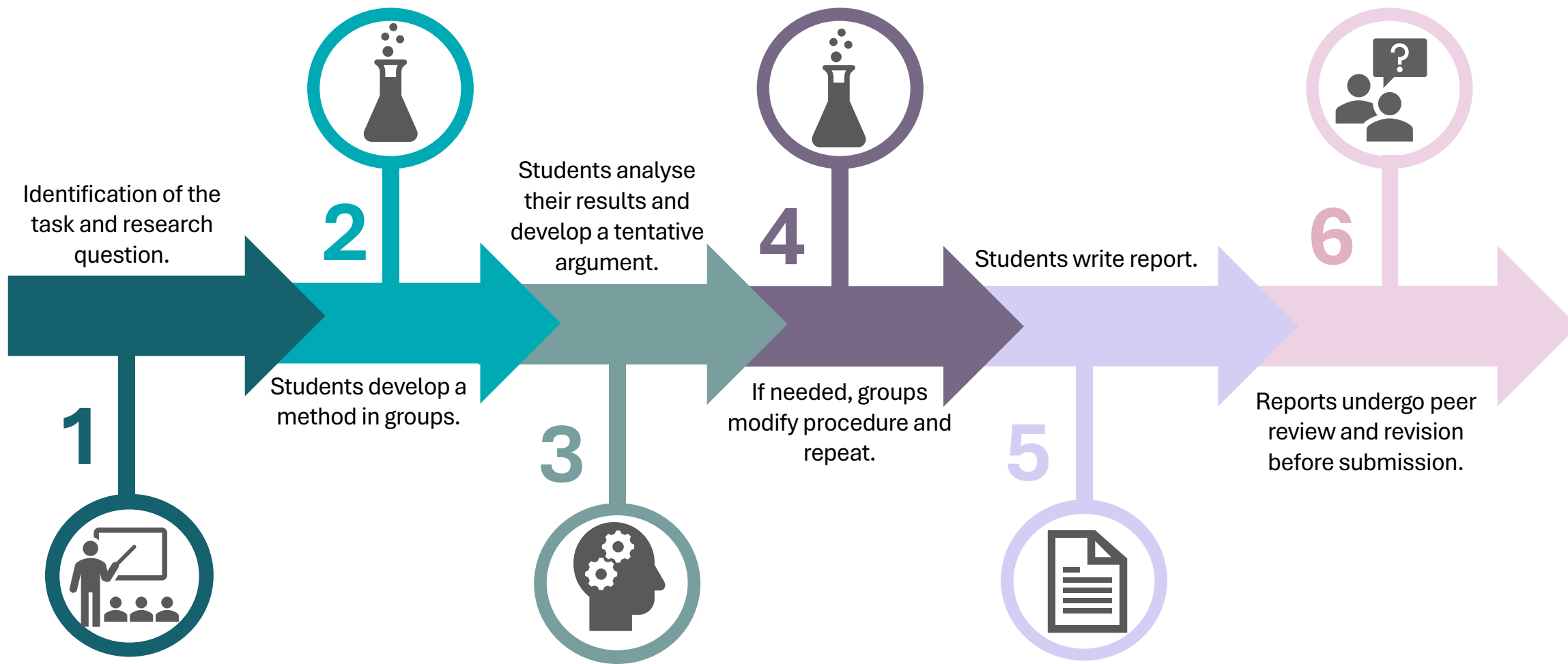
Literature:

“The learning benefits individual students (or pairs of students) derive from carrying out repetitive tasks clearly decline after the task has been performed a few times.”

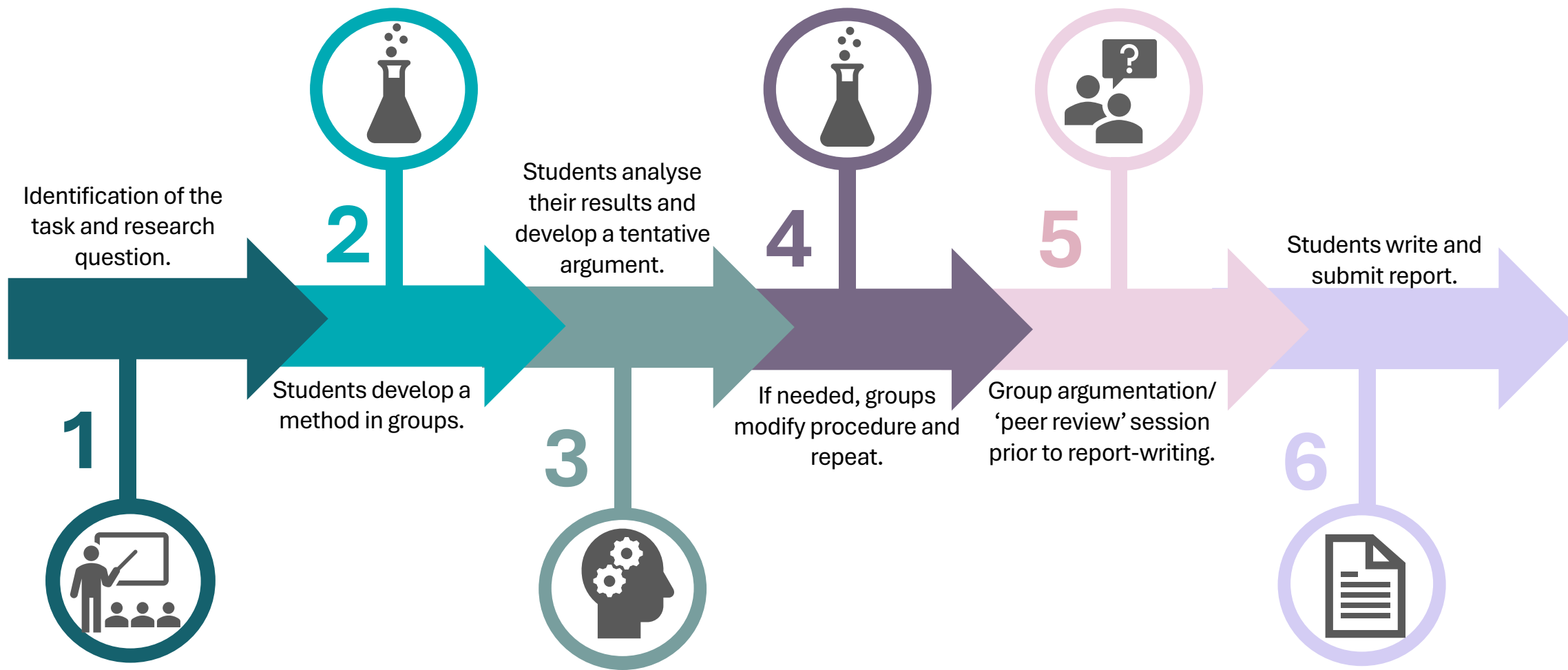
Skills for Future Chemists



Argument Based-Learning



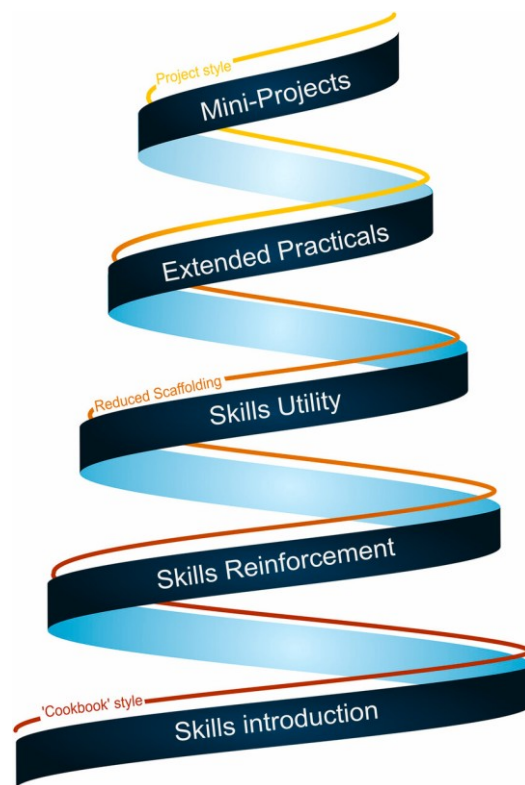
Revised One-day Model



Revised Intended Learning Outcomes

- To demonstrate the effect of solvent polarity on a solvatochromic dye.
- To identify preferential solvation trends in a two-solvent system through empirical investigation.
- **As a group**, to design and perform an investigation into the effect of addition of salts to a solution of solvatochromic dye.

Scaffolding/Prior Knowledge



This Lab:
Part C

Group-Based Experimental Design to
Investigate Halochromism

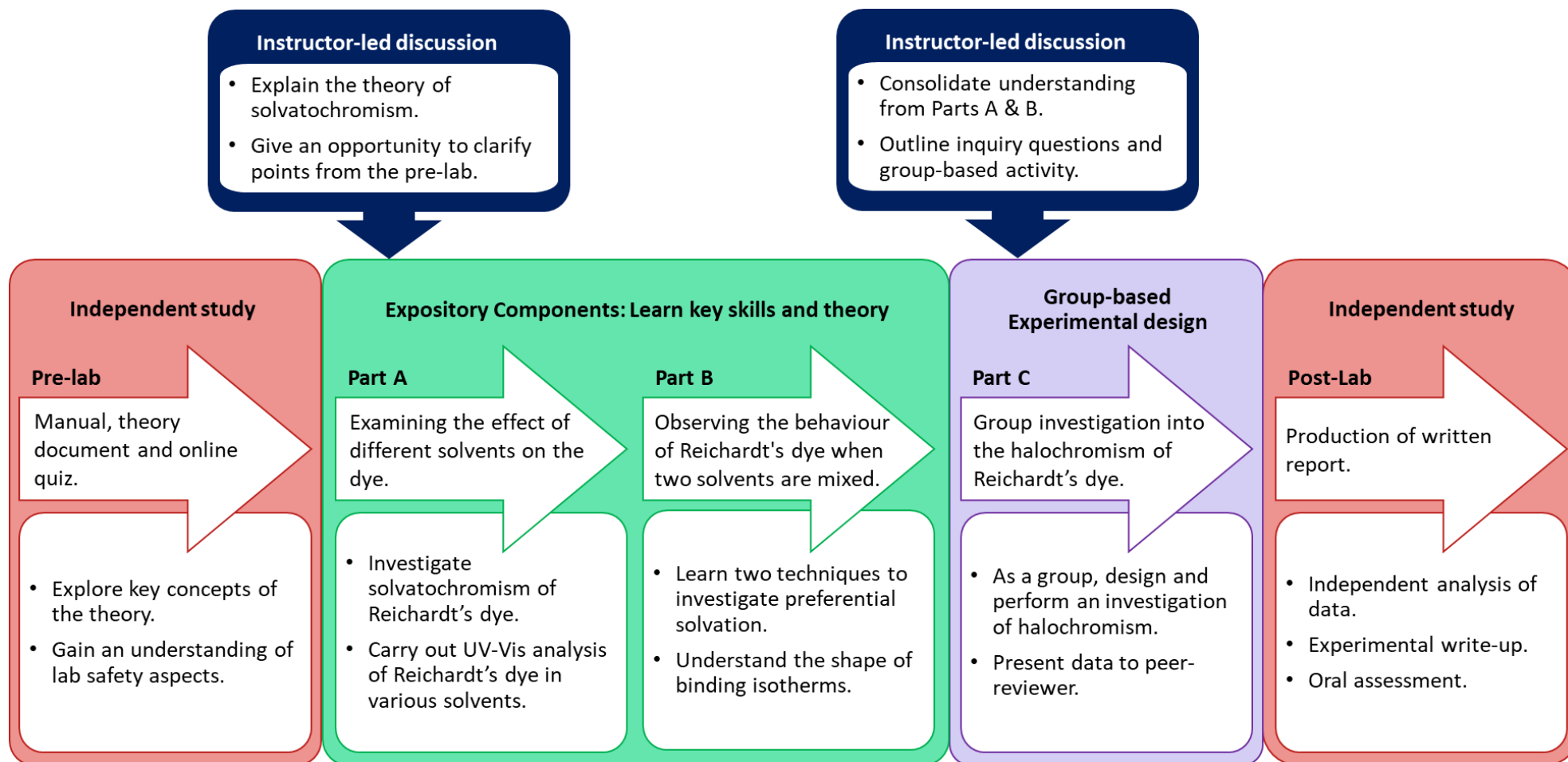
This Lab:
Parts A and B

Initial Investigation into
Solvatochromism and Preferential Solvation

Previous Lab: Kinetics of Oxidative Bleaching

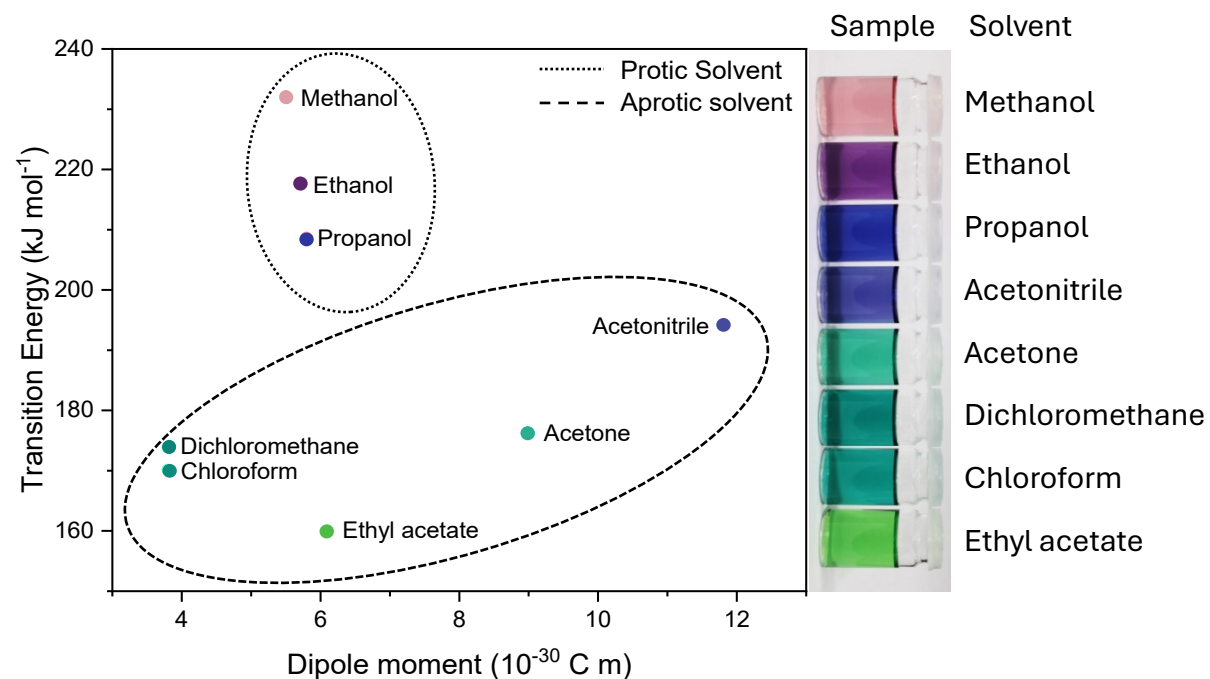
Previous Lab: Introduction to UV-Vis and Polarimetry

Session Structure

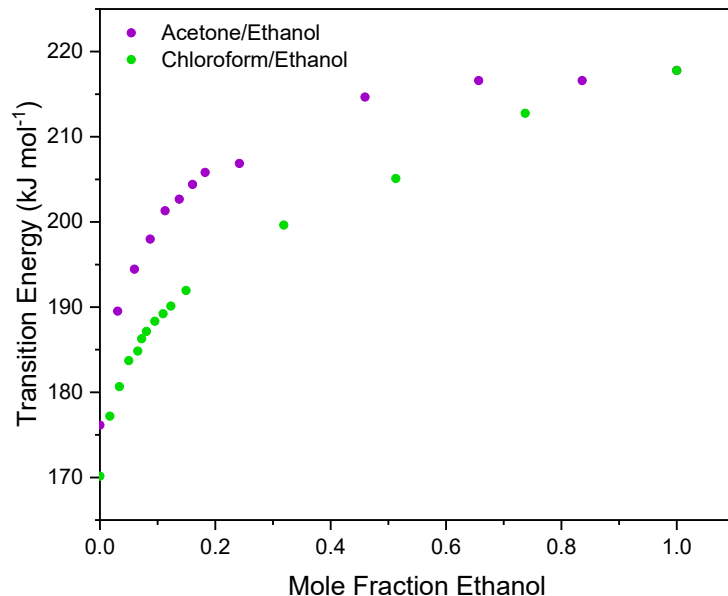


Revised Experiment – Part A

- Students make up a series of solutions of Reichardt's dye in various solvents, both protic and aprotic.
- Active discussion between instructor and students about the difference for protic and aprotic solvents.

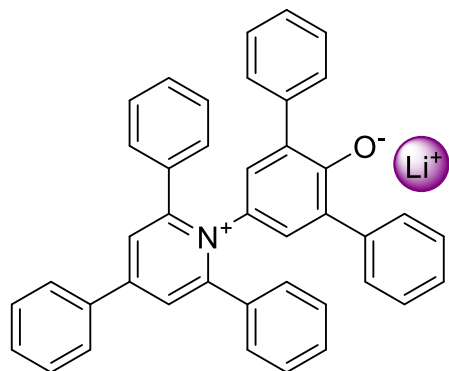


Revised Experiment – Part B

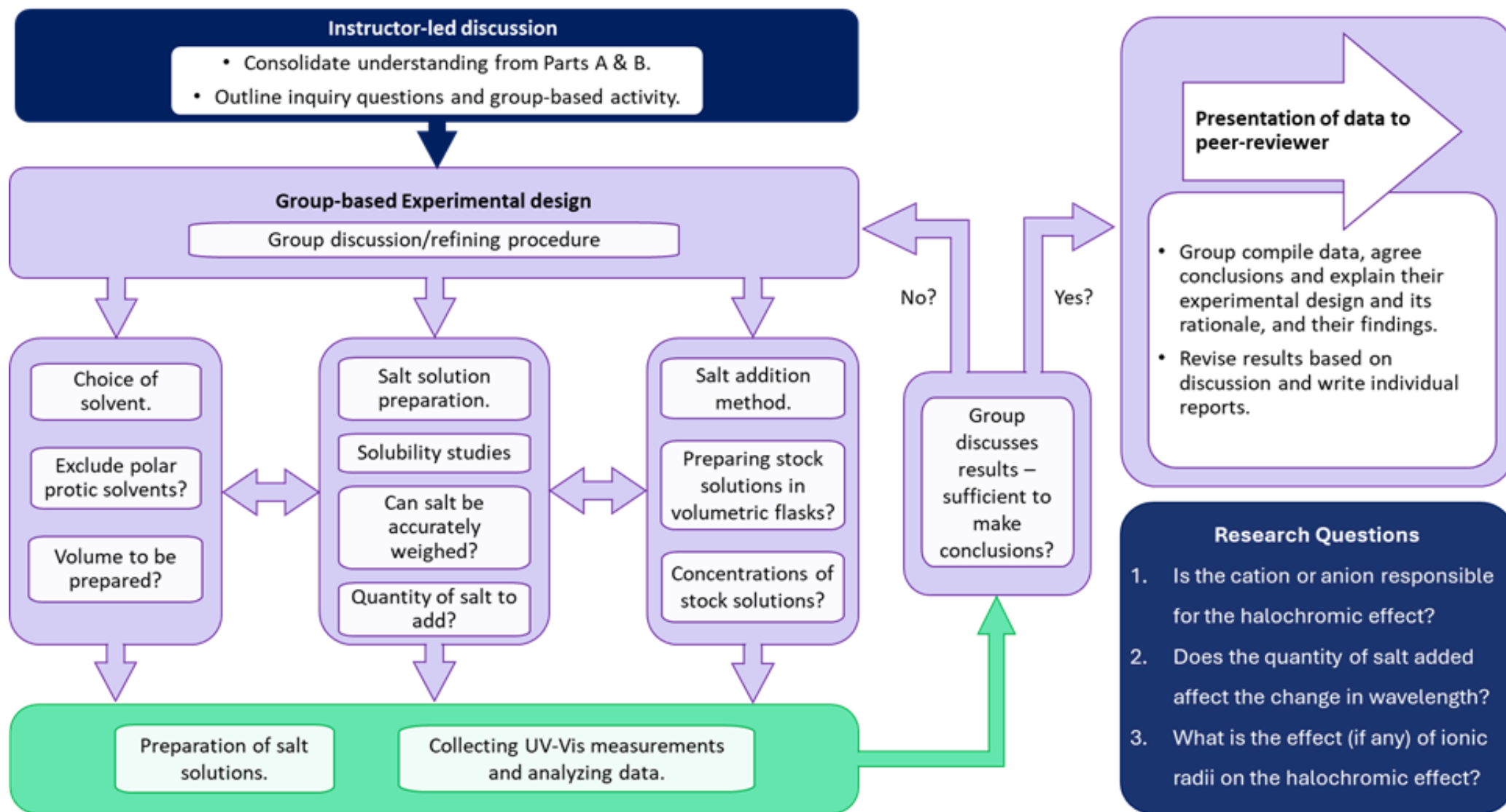


- Students explore ‘preferential solvation’ by adding increasing amounts of ethanol to dye solutions in chloroform and acetone.
- Pairs of students pair up to form groups, with each pair measuring one solvent mixture and comparing data.
- Students are shown two methods:
 - Preparation of stock solutions at various % v/v EtOH in acetone or chloroform.
 - Direct addition by autopipette of small amounts of EtOH dye solution.

Revised Experiment – Part C

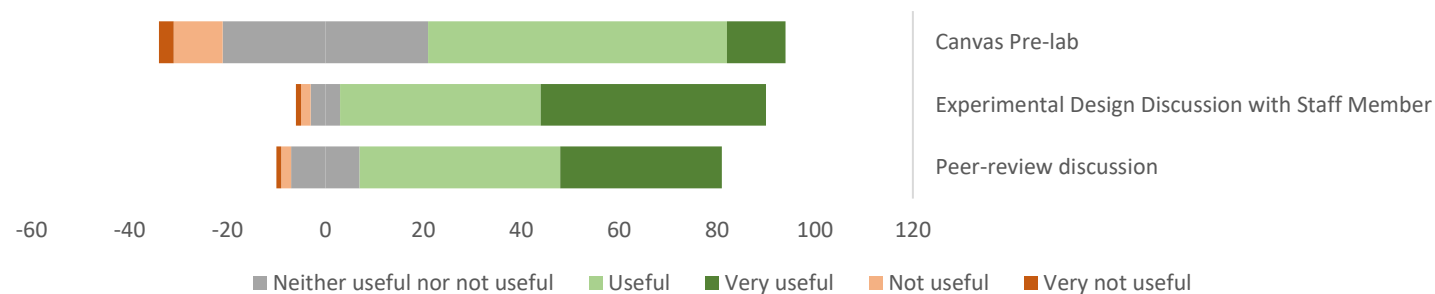


- A discussion is held to draw out key learning points from the morning.
- Investigative questions then set:
- **Investigate the effect that salts have on the colour of the solution (halochromism)**
 - Is the cation or anion responsible for the halochromic effect?
 - Does the quantity of salt added affect the change in wavelength?
 - What is the effect (if any) of ionic radii on the halochromic effect?

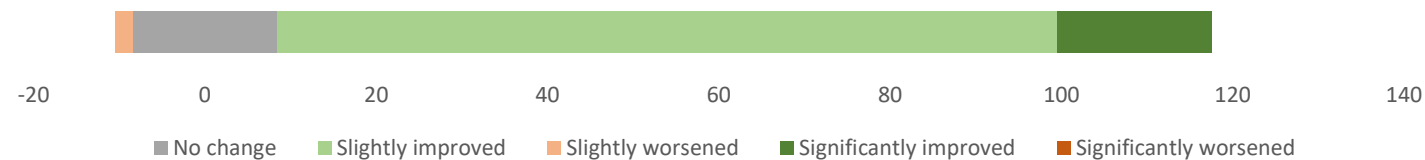


Student Feedback (N = 128)

Student perceptions of utility of instructor interactions:



Student perceptions of improvement of experimental design skills:



Improved engagement and design skills...

“I liked having to try to justify each decision we were making and also try to reason when the data didn't turn out the way we expected.”

“Loved the colours but mostly the creative element of designing the third part of the practical. I really enjoyed leading the team to achieve results that matched well with the theory.”

“The designing of the experiment as a group with less help [from lab staff] felt like a step up from practical chemistry in the past.”

“I enjoyed working as a group in part C, and felt that it helped us get an idea of how chemists work in the ‘real world’.”

... and theoretical understanding of solvation

“I can visualise it much better now. Also taking into account the solvent which will solvate the ions more or less depending on their size which affects their interactions with the dye.”

“Especially learning to consider how certain groups in a zwitterionic species can be solvated differently and to different extents by the same solvent. I also learnt about preferential solvation and halochromism (as well as solvatochromism).”

“I understand a lot more now about the ways solvents 'solvate' and stabilise different chemicals - this idea of a solvation 'shell' around a molecule was new to me but particularly interesting.”

Conclusions

- Successful implementation of a group-based guided-inquiry solvatochromism practical for first-year undergraduates.
- Judicious scaffolding introduces new techniques in the morning, allowing students to make experimental design decisions in the afternoon.
- Students and instructors report increased student engagement and theoretical understanding.

Future Work

- Consideration of research-like presentation of results.
- Discussion of team working and soft-skills in end of lab discussion.
- Rollout of similar group-working across other labs.

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