Structured Quantitative Inquiry Labs in First Year Physics

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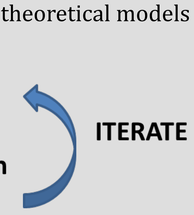
INTRODUCTION

Structured Quantitative Inquiry Labs (SQILabs) provide an environment where students develop and hone their critical thinking skills in a laboratory context. The key features of the course, used for PHYS 107/109 , Science One, and PHYS 119 are:

- A focused set of learning outcomes about data handling, graphical techniques, modeling, statistics, measurement, and uncertainties [1]
- Lab activities that are scaffolded to develop students' experimentation habits and scientific reasoning behaviours [2]
- The scaffolding takes the form of instructions and grading that encourage students to make comparisons, reflect on their results, and iterate to improve their experiments and theoretical models



- The scaffolding is faded out after 7 weeks

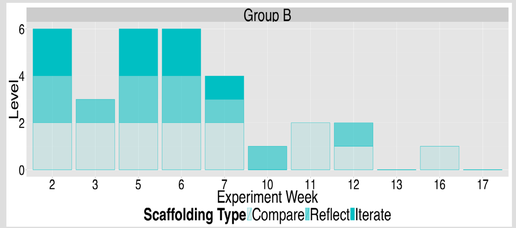
STUDYING THE SQILABS

Two groups of students in two different versions of the course were all given instructions and activities that built a basic set of data handling capabilities. Students did the same labs, with the same instructor in both versions.

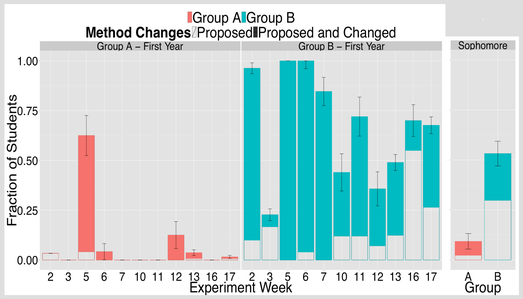
GROUP A: 135 students in PHYS 107/109 and Science One, taking the course without the introduction of scaffolding
GROUP B: 145 students in PHYS 107/109 and Science One received additional structure to encourage a more iterative approach to experimentation

RESULTS

The students were given scaffolding in both their instructions and in the grading scheme, with distinct guidance to Compare, To Reflect on the Comparison, and To Iterate. With the degree of scaffolding of each behaviour ranked from 0-2, the overall strength of the guidance on a scale from 0-6 is shown below.
Guidance is mostly faded out after week 7



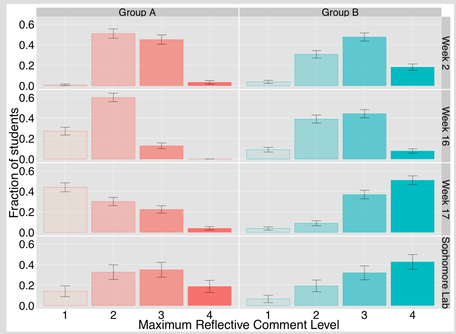
Students lab notebooks were analyzed to determine whether or not they had proposed, or proposed AND executed, changes to their experiment or model.
Group B, who received the scaffolding, continued to exhibit this behaviour even after the guidance was removed.



Comments in students' notebooks were rated using an adaptation of Bloom's taxonomy.

Level 1 comments remarked on the outcomes of analysis (application without interpretation)
Level 2 comments analyze or interpret data
Level 3 involves synthesis of multiple ideas
Level 4 involves evaluation of the analysis in light of the synthesis

Highest level reached was recorded for each student.



The quality of students reflective comments was much higher for Group B, who received the scaffolding. By the end of the course, the improvement in their scientific reasoning was dramatically improved, and this improvement continued into a second year laboratory course

STUDENT COMMENTS

"When I'm reading about something or solving physics problems or just reading about physics concepts, the idea of me being a physicist in that sense is very far fetched…[the lab] helped me think about a bunch of data that I have in front of me, that looks like chaos, in a more scientific way…

[The lab] integrates everything so much more and it helps me see myself as a scientist way more than all my other classes, because those are just putting information… giving me information, rather.. It helps me actually reach in and realize, 'oh, this makes sense! I can actually do this too,' rather than just memorize a textbook."

ACKNOWLEDGEMENTS

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REFERENCES

[1] J. Day, and D.A. Bonn, Phys. Rev. ST Phys. Educ. Res., 7(1), 010114 (2011)

[2] N.G. Holmes, C.E. Wieman, and D.A. Bonn, PNAS 112, 11199 (2015).