Measuring Student Attitudes and Performance in order to Improve Future Performance and Enrolments in Senior Science Subjects

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Abstract

With increased demands for scientific literacy with the impending changes to external assessment in Queensland, whereby 50% of a student's results in senior science and mathematics will be based on external assessment, it is important to incorporate more standardised assessment into a middle school's program so that students have the requisite literacy skills and self-efficacy to be successful throughout the process. This project aimed to examine whether external examinations such as the International Competitions and Assessments for Schools (ICAS) Science test, could correlate with internal assessment outcomes, and whether the increased use of scientific literacy through these leads to greater confidence when selecting senior science subjects. Two cohorts of students (Year 9 and Year 10) were included in the research and student learning outcomes post intervention were analysed to determine correlations between the ICAS science results and internal school-based assessment. The results suggest that targeted intervention does improve student self-efficacy and furthermore showed a positive correlation between the external ICAS science test and internal assessment.

Introduction

There are multiple external examinations that are used in Australia to inform teachers as to their students' strengths and weaknesses. These include NAPLAN, ICAS (International Competitions and Assessments for Schools) Science, Big Science, Australian Science Olympiads, and PATScience (Progressive Achievement Test in Science). The imminent senior assessment environment in Queensland will include school-based assessment and common external assessment, with external assessment contributing 50% towards a student's results in science and mathematics subjects (Queensland Curriculum and Assessment Authority, 2016a).

This project aims to examine whether external examinations such as ICAS Science could correlate with future internal assessment outcomes, and ultimately lead to higher confidence in senior science subject selection. If there is a correlation, then teachers could use this to identify weaknesses in students' skills set and could inform teacher practice moving forward.

Assessment is not a stand-alone practice for any educator. Goss, Hunter, Romanes and Parsonage (2015, p. 40) suggest that, "schools should develop a plan to collect robust evidence of student learning" (what each student is ready to learn next, and how much their learning has progressed) and use this datum to target teaching and monitor student progress. Masters (2013) states that the unifying principle of any assessment is "to establish where learners are in their learning at the time of assessment"; in essence linking assessment directly to student learning.

As student populations become more diverse, teachers face the challenge of providing differentiated instruction to students with a wide range of knowledge and skill levels. By improving skills related to collecting, analysing, and interpreting student assessment data, teachers will be potentially better equipped to adjust their instruction to accommodate the needs of individual students (Means, Chen, DeBarger, & Padilla, 2011).

Targeted teaching is a tool that can lift student performance; it requires teachers to identify prior knowledge and adapt their teaching strategies accordingly. Goss et al. (2015) suggest that "high quality standardised assessments that are well-designed and selected for the specific purpose required should be incorporated into every school's assessment program". Large quantities of data that would be generated from ubiquitous standardised tests are problematic without meaningful analysis. Teachers need to see a direct correlation between student performance and teaching strategies. When teachers are well equipped to use student performance data, they are more likely to successfully "target teaching and track student progress over time" (Goss et al., 2015).

The data generated from assessment can provide timely feedback to assist learning (Hattie & Timperley, 2007). When students are able to see their own progress in tasks that were originally challenging, they can be motivated to continue with their learning. This information coupled with meaningful feedback, could also serve as a way to establish goals. ICAS Science provides students with longitudinal data, allowing students to track their own progress. Student success may lead to increased motivation towards their studies. There are various perceptions of success in terms of academic achievement. For the purpose of this project, success in science is defined as the number of students choosing a senior science subject.

Background

This project was undertaken at a girls-only metropolitan school in Queensland, Australia, which caters for students from Kindergarten to Year 12. The school has a population of 730 students with approximately 500 in the senior school. There are 14 science teachers working in both the senior and primary school.

The level of participation in science at the school is strong, with 85% of students studying one or more senior science subjects in 2016. Engagement in science at this school, where the proportion of Year 12 girls in 2016 undertaking Biology, Chemistry and Physics was 49%, 42% and 19% respectively, varies significantly from current trends in Australia (Chubb, 2012; Queensland Curriculum and Assessment Authority, 2016b) with comparable figures being 20%, 10% and 4% for Year 12 girls in schools throughout Queensland. Year 12 Queensland senior science enrolments for Biology, Chemistry and Physics have stayed at a stable percentage during 2013–2016 (Queensland Curriculum and Assessment Authority, 2016b).

A deliberate strategy over the last five years has been to utilise specific language and criteria from the senior syllabi (of Biology, Chemistry and Physics) in Year 9 and Year 10 Science. Furthermore, the school has overtly unitised the science course for these years, having whole terms as units for each of the Australian Curriculum subjects of Biology, Chemistry, Earth & Environment and Physics. This strategy was implemented so that students commencing Year 11 science subjects did so within an established language and subject-awareness framework.

In order to address student attitudes to science in the middle years of schooling, this project aimed to familiarise students with specific process-driven scientific language (e.g. as used in ICAS test papers). ICAS is a skills-based, multiple-choice test administered annually by the Educational Assessment Australia (a subsidiary of UNSW Global). It addresses five key skills areas: Observing/Measuring, Interpreting, Predicting/Concluding, Investigating and Reasoning/Problem Solving (Educational Assessment Australia, 2017).

The 2014 ICAS Science results for two cohorts (Year 7 and 8 students in 2014) identified the need to address weaknesses within the 5 key skills areas. Data analysis of the 2015 ICAS Science test for the same two cohorts (Year 8 and 9 students in 2015) revealed that the key skill areas of Observing/Measuring, Interpreting and Investigating were critical in improving learning outcomes in science (Martin, MacDonald, & Hicks, 2017 in review).

Methodology

Attitude
The research team initially sought to identify perceptions held by students through the use of Attitudinal tests, utilising the Year 9 (2016) student group (54 students) to provide feedback regarding their attitudes towards STEM through a S-STEM test (Friday Institute for Educational Innovation, 2012).

Practice
The participants in this cycle included students in Years 9 and 10. The staff involved were the teachers of the Science classes in these year levels, with a focus on practicing/developing strategies in the three key skills areas. This was done in small groups of three to four students, based on skill capabilities (identified from 2015 ICAS data), over a period of four weeks prior to formal testing using ICAS Science past papers. A variety of learning activities were incorporated, such as student-led problem-solving strategies and use of time constraints. The goal of this was to remove (or lessen) the effect of disengagement due to a lack of perceived capability, and in turn, to encourage success, by overcoming the language barrier associated with science-based questions.

Application
All Year 9 and 10 students participated in the official 2016 ICAS Science test.

Perception
Prior to ICAS Science 2016 results publications a random group of Year 9 and 10 students (~10% of cohorts) completed a follow-up survey which probed the benefits of ICAS practice sessions and the predictive link between ICAS and science results.

Data Analysis
Results from the ICAS Science 2016 paper were analysed and compared to the 2015 data. The ICAS Science results were compared to results from Science assessment.

Results

We found that Year 9 students showed confidence in their ability to achieve in science and felt that science was important for their future, as seen in Figure 1. Students were confident that they would do well in their studies (Figure 2).

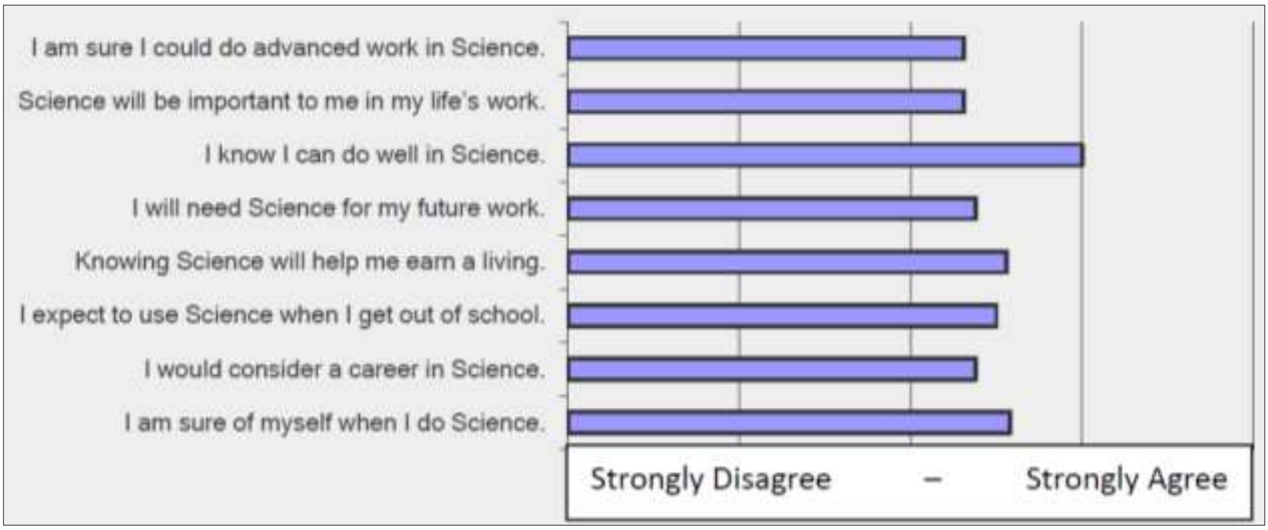

Figure 1: S-STEM summary perceptions about science

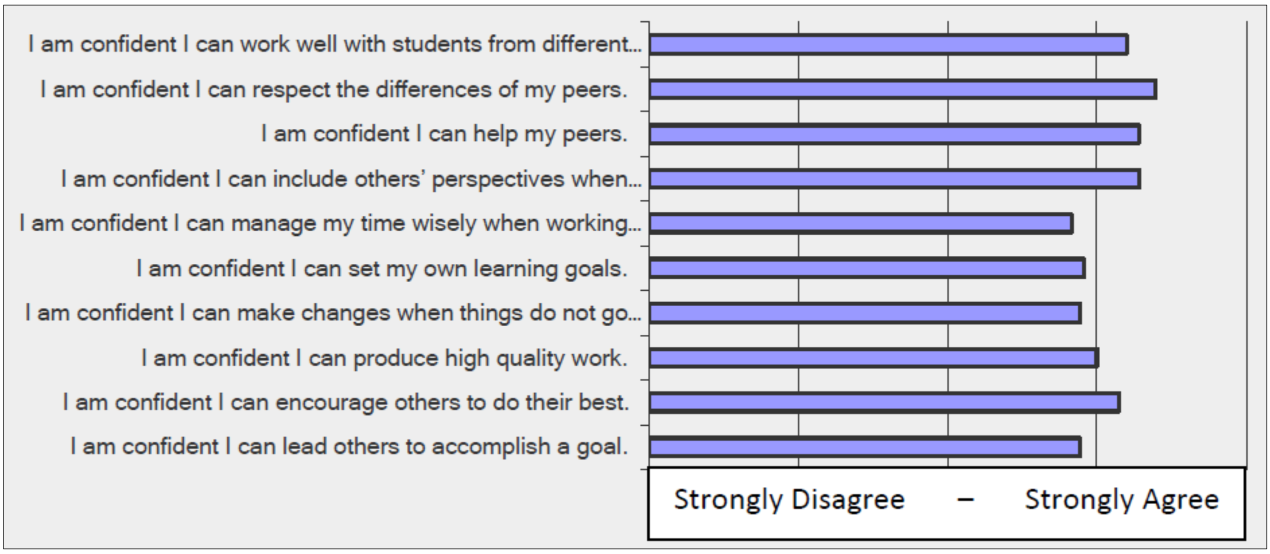

Figure 2: S-STEM summary of self-perceptions

The main findings were that the Year 9 and 10 students improved their overall results in the 2016 test, compared to the 2015 ICAS results (Figure 3). For the year 9 students in 2016, there was a two-fold improvement from 2014, with these factors combining to indicate that the cohort is stronger overall:

- Their overall average results are closer to the Australian average over the two-year period. This indicates an improvement across the whole cohort.
- There is significantly less (almost 25%) variance in the results for this cohort.

Similar trends in the data were seen in the Year 10 ICAS results for the same period.

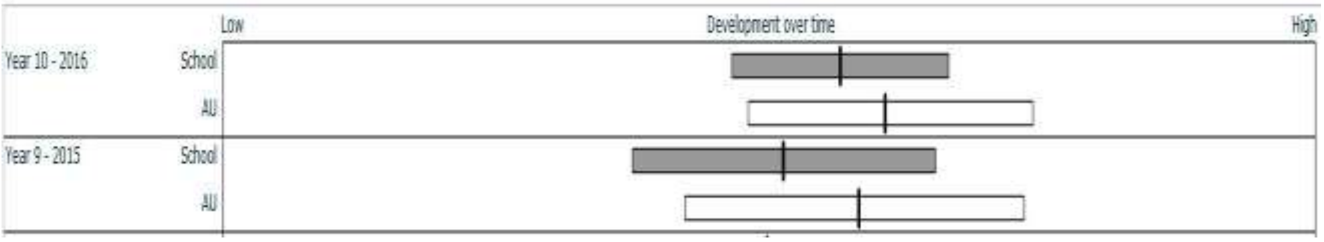

Figure 3: Comparison of ICAS results (Year 9, 2015 and Year 10, 2016)

When considering results, it is worth identifying that all Year 7–Year 10 students at this school are required to participate annually in the ICAS Science competition. The Australian national average has a positive bias, as most students elect to participate in this competition. This would suggest that the majority of these students have a vested interest in Science and therefore, perhaps are more likely to achieve at a higher standard.

Summary Student Perception Data

- 92% of students felt that their science results would be better than their ICAS result.
- 92% of students felt that there was no predictive link between results in ICAS and science.
- 75% of students felt that there was benefit for Science understanding in undertaking ICAS.

Most students felt that the ICAS preparation familiarised them with the style of questions and provided them with problem-solving strategies. Students noted that they felt more confident when approaching science assessments in general and were better prepared to deal with the stress of exam situations.

ICAS data compared to internal science results (as of June 2016) are shown in Figure 4, where a clear positive correlation of these two data sets is seen. Despite some volatility in the data, it can be seen clearly that Year 9 and Year 10 students who performed well on school science assessment also generally performed well in the external ICAS task. There was consistently more variation between best and worst performance in the results for the external (multiple choice) exam

Figure 4: Comparison of Year 9 internal science results with same cohort ICAS results for 2016

Similar trends in the data were seen in the Year 10 results for the same period.

The dominant trend of the correlation between internal science results and external ICAS Science results can be seen when internal results are expressed as Grade Point Average (with a range of one to 15), as in Figure 5. Generally, it can be seen that students performing well in science, do so in both forums of internal and external assessment.

Whilst ICAS Science is designed to assess skills rather than knowledge (which is assessed internally), the results are comparable. Consequently, the ICAS Science test is suitable as a school internal assessment tool.

It is significant that this graph shows a linear regression trend line with a negative y-intercept. This indicates that it is unlikely for students to gain marks in the multiple choice external exam, unless they were capable of gaining marks in the internal assessment. In contrast, if the intercept had been some positive number, it would mean that students are likely to get points on the multiple-choice test even when they get zero on internal assessment. A similar correlation was evident in the Year 9 cohort.

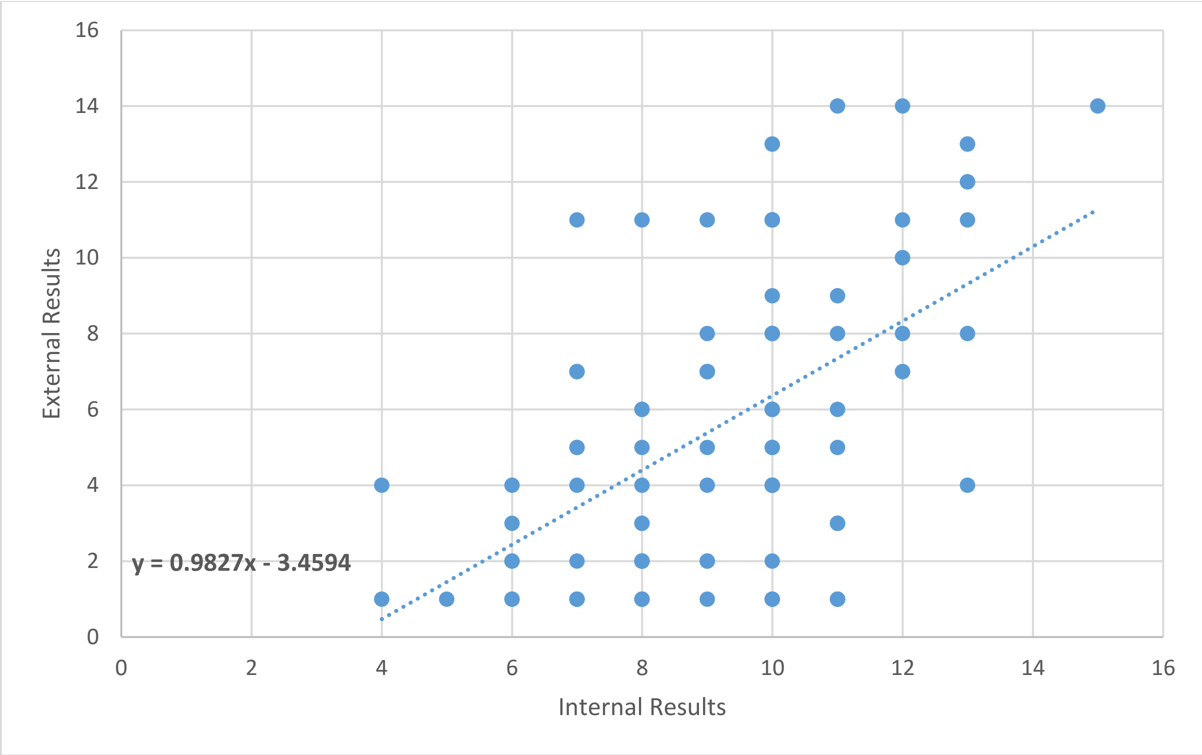

Figure 5: Scatter diagram of Year 10 science results with same cohort ICAS results for 2016

At this school, senior science subject enrolments for Year 11 2017 are at a higher level than when the project commenced, as seen in Figure 6. Therefore, it could be interpreted that this intervention has had a positive flow-on effect.

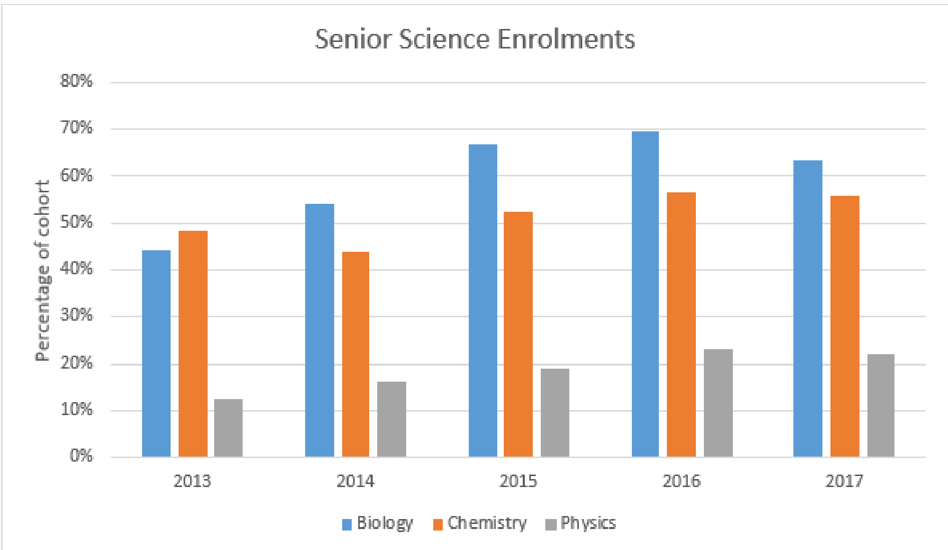

Figure 6: Year 11 senior science enrolments at the school from 2013 to 2017

Discussion

This research project determined that by providing students with opportunities to explore and discuss strategies when preparing for external examinations, student confidence could be enhanced. Bandura (1982, pp. 200-201) defines self-efficacy as a person's judgments about their ability to "organize and execute courses of action required to deal with prospective situations that contain many ambiguous, unpredictable, and often stressful, elements". Consequently, the stress association with a situation such as an external examination can be minimised through targeted interventions such as our small, focused and, periodic group work. Student feedback suggests that working in small groups, based on skill capabilities, assisted with their preparation for the ICAS test.

Research also suggests that students are more likely to challenge themselves with difficult tasks and be intrinsically motivated when they have a strong sense of self-efficacy (Kirk, 2016). This could relate to selecting challenging senior science subjects, as students perceive these to be more difficult.

Many studies have shown that self-efficacy and its sub-skills are strong predictors of academic achievement (Wigfield, Eccles, Schiefele, Roeser, & Kean, 2006; Zimmerman, Bandura, & Martinez-Pons, 1992). Therefore, the targeted intervention conducted in this project, could be suggested to have a positive impact on student performance. Collaborative learning through the use of group work further enhances self-efficacy as it has been shown that students who worked together promoted "more positive self-evaluations of capability and higher academic attainments" (Kirk, 2016; Fencl and Scheel, 2005). "Students' self-confidence is built, not through success on easy tasks, but when they are able to see the progress they are making, when they appreciate how the quality of their work has improved" (ACER, 2013).

This project evidences the value of external examinations such as ICAS Science, through the direct correlation between the external and internal assessments. This result was somewhat surprising, as the ICAS Science test focuses on skills whereas the internal assessment tests both skills and knowledge, suggesting that practice in context enhances skills. Furthermore, if targeted intervention is provided prior to the ICAS science test, then this would have a positive outcome for student achievement internally. This targeted intervention could translate into other learning areas within the school, particularly in developing comprehension and problem-solving skills. This intervention could have a profound impact on the school culture, both for teachers and the wider school community. Firstly, there would be a benefit in monitoring students' progress longitudinally in both internal and external assessment and secondly, intervention could occur when a discrepancy appeared between the two.

Conclusion

This project aimed to improve student learning outcomes in science through targeted intervention using the ICAS Science test as a tool. Our measure of success was the number of students choosing a senior science subject, and since the commencement of this study, student enrolments in senior science subjects have increased. Our intervention of peer-driven group work designed to enhance problem-solving skills, led to greater student self-efficacy, and ultimately improved learning outcomes for students. This study also impacted on teacher practice as teachers were provided with an opportunity to facilitate small focused group work, which was informed by previous ICAS Science results and data analysis. This led to improved teacher pedagogy and most importantly, increased teacher self-efficacy.

At the commencement of this project, our thoughts were that the ICAS Science test results would not correlate with internal assessment, as ICAS Science focuses on skills rather than knowledge. However, as the project progressed, it became apparent there is a greater contributory relationship between skills and knowledge. Therefore, it might be possible that if there was considered focus on the three identified key skill areas, that there would be a net positive outcome for students' internal assessment results.

The findings reported in this paper have only provided an initial insight into the data's full potential. Extensive data analysis would provide future areas of research and this would extend into addressing correlations of ICAS Science, Mathematics and English data, to reveal their possible predictive values.

Upon reflection, alternative research questions that draw upon student and teacher perceptions of self-efficacy would be beneficial to further substantiate and evaluate the effectiveness of targeted intervention. It should not be concluded that the pedagogical approaches used in this study are the sole contributors of the success observed. Many pedagogical approaches could have a similar impact and it would be useful to identify those approaches that would most impact student self-efficacy.

One further consideration from this project is the need for teacher professional development in the area of data analysis, as there were significant analytical, skills required in order to review data meaningfully. If we are to go down the pathway of utilising external data from sources such as ICAS and NAPLAN meaningfully, then teachers should be supported so that they are better equipped to act on data to inform their teaching pedagogy.

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