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Differences in Perception Between Students and Teachers of High School Science: Implications for Evaluations of Teaching and Classroom Evaluation.

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Abstract: The science teacher in the modern high school acts as the designer and driver of the in-class practice. In this role, the teacher must broadly assess the effect of the practice on the student. This would rely on accurate self-knowledge of how they act in class and impact their students. In this study we explore these issues by comparing the difference in responses of 86 teachers and 2512 Year 9 and 10 students to an instrument probing their perceptions of their in-class practice. We report two significant findings. First, not only do teachers constantly positively overrate their in-class practice but secondly, these perceptions are completely unrelated to how their students see their classrooms. This implies that using teachers as the sole source of evaluation about their own classroom practice is problematic and that evaluation should always be endeavoured to be undertaken at the level of both teachers and students.

Keywords: science education, teacher evaluation, classroom evaluation, student perceptions, teacher perceptions

Introduction

In the developed world, high school student interest in science has been waning for decades and, in response, has led to many national reports and working groups calling for substantial reforms. (e.g., AAAS 1990, Millar & Osborne (1998) International Bureau for Education 2001, Drury & Allen 2002, Committee for the Review of Teaching and Teacher Education 2003, Lyons & Quinn 2010, Goodrum et al. 2012). Concurrently, a large body of research has been undertaken into students' opinions of their experiences of school science and independently of their teacher. Reviews by Osborne et al. (2009) and Tytler & Osborne (2012) provide an in-depth overview of recent work and the main points of interest for this field. In particular, they focus on the instruments in the literature used to measure students' attitude towards science, the generation of questions from new datasets, the work on identity as well as the impact of age and gender.

The central instrument, and theoretical structure, of this field has been based around the quantitative 'Questionnaire on Teacher Interaction' (Wubbels et al., 1985). The Questionnaire of Teacher Interaction (QTI) questionnaire has been used to probe students' perceptions of their teachers as well as the teachers' perceptions both of themselves and the ideal. For those that have looked at interpersonal behaviour, they have generally found great differences between student and teacher perceptions (den Brok et al. 2006). In general, the teachers' perceptions have been "positively" skewed in comparison to their students' perceptions. The teachers rate such aspects as 'leadership', 'helpful' and 'understanding' behaviours as higher than their students, while rating aspects as 'uncertain', 'dissatisfied' and ' admonishing' lower than their students. These differences were also generally linked to certain instructional behaviours and tend to be correlated with higher student motivation and understanding.

Most importantly, only a small number of studies showed non-significant differences between teacher and student perception, but overall, generally moderate to strong effect size differences are found and these tend to be positively skewed by the teacher (Wubbels and Brekelmans 2005). This is generally seen as a symptom of wishful thinking on the teacher's behalf. In general, teachers' perception of themselves is typically (66% of cases) less than their perception of the ideal. In turn, students' perceptions of teachers are lower than the teachers' perceptions of themselves. For some teachers (33% of cases), the teachers' perception is lower than the students' perception, which can be seen as the teacher protecting themselves from confrontation with negative student perceptions.

A finding of particular concern came from Wubbels and Brekelmans (2005) and was seen in the correlation between the level of disagreement between students and teachers and the students' perception of the teacher. Their results indicated that the greater the disagreement between the two groups, the more students perceived their teacher as uncertain, dissatisfied and admonishing. However, they also reported that when teachers reported higher perceptions of their own leading and their helpfulness and friendliness, this was positively related to student achievement and motivation. We interpret these findings as indicative that ideally, teachers should have a positive perception of their teaching (e.g. Deehan 2017), as this implies that they are more confident in their instruction. But, in order for this have a positive impact on student learning, this perception should not deviate too largely from those of their students.

Little research has been undertaken that directly compares students' and teachers' perceptions of their science classroom in terms of those aspects identified as specifically important for inquiry-based science learning. This is the case even though student and teacher perceptions of their classrooms and their interaction have been shown to form an important factor in the socio-psychological makeup of the classroom (Myers & Fouts 1992). One tool that has a larger focus on this domain comes from Rentoul and Fraser (1979). They created the Individualized Classroom Environment Questionnaire (ICEQ) in order to address particular aspects that are characteristic of an individualized setting and inquiry-based learning classroom, that are seldom incorporated into other existing classroom environment questionnaires.

The ICEQ comprises of five dimensions: personalisation, participation, investigation, differentiation and independence. Fraser (1982) applied the ICEQ in 34 junior high school classes in New South Wales in order to investigate both student and teachers' preferred and actual views of the classroom environment. The two main findings were that for four out of the five dimensions (personalisation, participation, investigation and differentiation), teachers reported more positive actual perceptions than their students. Also, both groups reported they would prefer to see a greater emphasis on these same four dimensions. For the remaining dimension (independence), students reported they would prefer higher levels but teachers considered the actual to be appropriate. These findings indicate that there is simply not enough individualization and inquiry within the classroom and both teachers and students would like to see more.

In an endeavour to improve the experience of the science education experience of students, it is via the teacher that any of these changes are undertaken. The teacher is well-known to have the largest impact on student learning within the classroom (Rowe 2003, Hattie 2003, 2008). In the classroom, it is the teacher who must actively monitor the level to which their classroom matches, or diverges, from the ideal classroom and with this information decide on a corrective course of action, if one is available. If the teachers' perception of the classroom is inadequate or skewed, matching their in-class practices to what students need and perceive becomes problematic.

In this paper, we seek to compare the teacher and student perceptions of their science classroom with a focus on those elements identified as important to high school science education in a similar manner. The instrument we use, the Secondary School Science Questionnaire (SSSQ) is a slightly modified version based on the initial work of Goodrum et al. (2001), and used over the last decade by others (Danaia 2006, Goodrum et al. 2007, 2012, Danaia et al. 2013, Danaia et al. 2017). The SSSQ has considerable overlap with the QTI in conceptual content while containing science specific items as well.

We begin this paper with a demographic definition of our teacher and student samples and comparison to the general Australian context. We then describe the instruments themselves before undertaking two main avenues of analysis. First, we explore the mean differences overall between the teacher and student cohorts. Second, we crossmatch the student and teacher databases such that we can compare individual teachers' responses to the mean scores of the aggregated data for each class of students. We then discuss the implications of these results.

Teacher and Student Sample

Teachers

Our sample consists of 86 science teachers who were all involved in the Space to Grow astronomy intervention project (Danaia et al. 2012) in NSW, Australia. Each teacher undertook the Teacher Secondary School Science Questionnaire (TSSSQ) survey in the period 2010-2012. The survey was administered via two means. The first was via an online survey using Surveygizmo (http://www.surveygizmo.com/) and the second was via the traditional paper survey. Each teacher was mailed the paper version but given a web-link to undertake the survey online if they so wished.

In our sample there were 38 females (44%) and 48 males (56%). The age range distribution of our teachers is similar ($X^2(8)=12.356, p=0.089$) to that found in the 2007 Staff in Australian Schools SiAS study (McKenzie et al. 2008), shown in Figure 1. The average-age category in our sample, the 41-45 year old age range, is similar to that also found in the SiAS report.

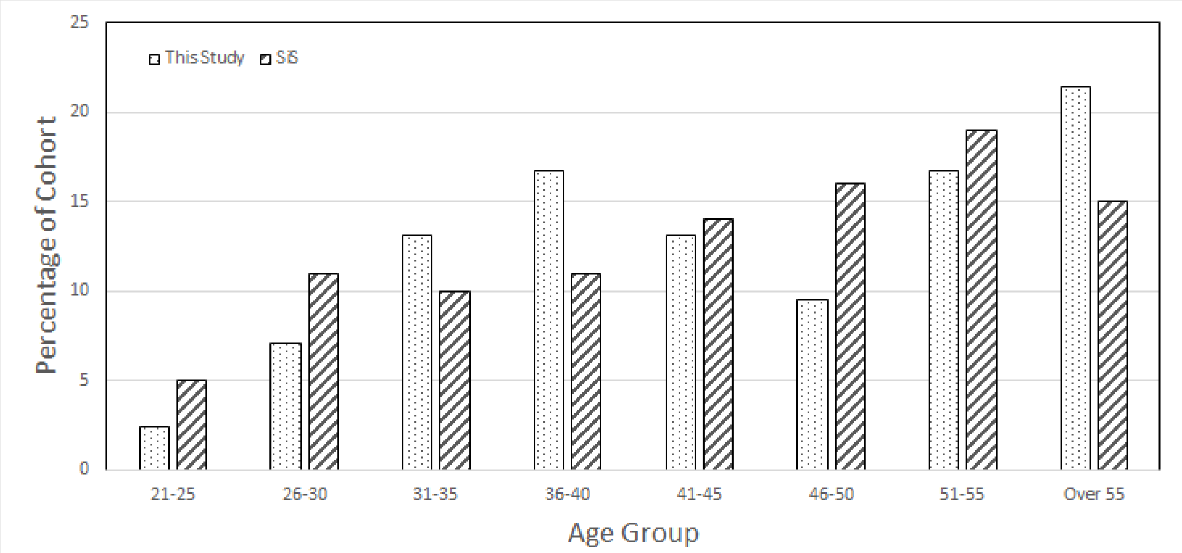

Figure 1: Age distribution of teachers in our sample compared to that in the Staff in Australia's Schools 2007.

Most teachers in this sample were classroom teachers (70%) while a substantial fraction were Heads of Departments or Subject Co-ordinators (28%) with one assistant principal. The majority were employed on a full-time permanent basis (91%), with the rest being casual, temporary or part-time. In the SiS report, 82% of teachers are employed full-time. Most teachers in our sample taught in a Catholic Systemic school (58%) or in Government schools (32%) with 7% in Catholic Independent schools and 3% in Independent schools.

The number of years the teachers had been teaching science at their school was compared to the SiAS report in Figure 2. The values are statistically significantly different, with a ($X^2(6)=15.213, p=0.009$). The differences seem to be in the lower age ranges and show an excess of beginning teachers and fewer teachers in the 1-3 year bracket in our project, although the values of both the SiS and our sample would agree very well overall if we simply considered the two lowest categories together as 0-3 years at about 40% of the sample each. -There was no information on how long teachers had been in teaching in total in the SiS report, so we only present our own results for this in Figure 3.

The majority of teachers (70%) had a Bachelor of Science as their science qualification, although only 2% took this to the Honours Level, a level which normally requires a research project to be undertaken and a report generated. The next most common degree was a Bachelor of Applied Science (9%), followed by an Integrated Bachelor of Education degree with a specialisation in Science and Education (5%). Data on the nature of their major streams of study was only collected later in the project, so only 25% of the teachers provided this information. For those that did, the fields of scientific study were, Biology (32%), Other (23%), Chemistry (18%), Physics (14%), Geology (9%) and Mathematics (4%). About a quarter (28%) of the teachers stated that they had undertaken astronomy, other than within the Space to Grow project, at some formal level, whether through a university subject in their degree, or through professional development or other type of course such as a Master of Science (Astronomy) studied by distance education.

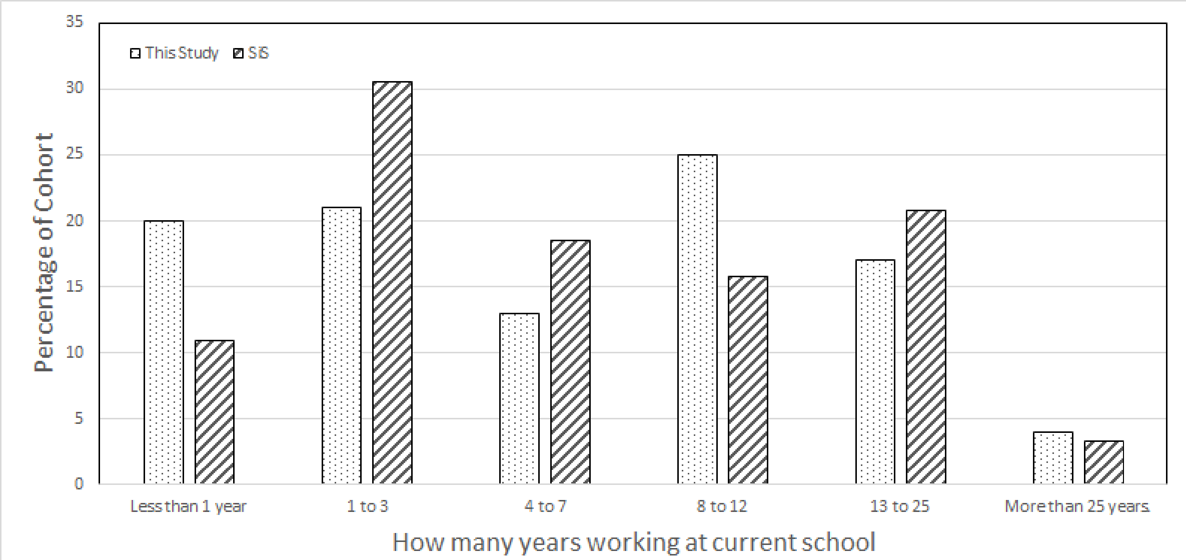

Figure 2: Years spent teaching at current school.

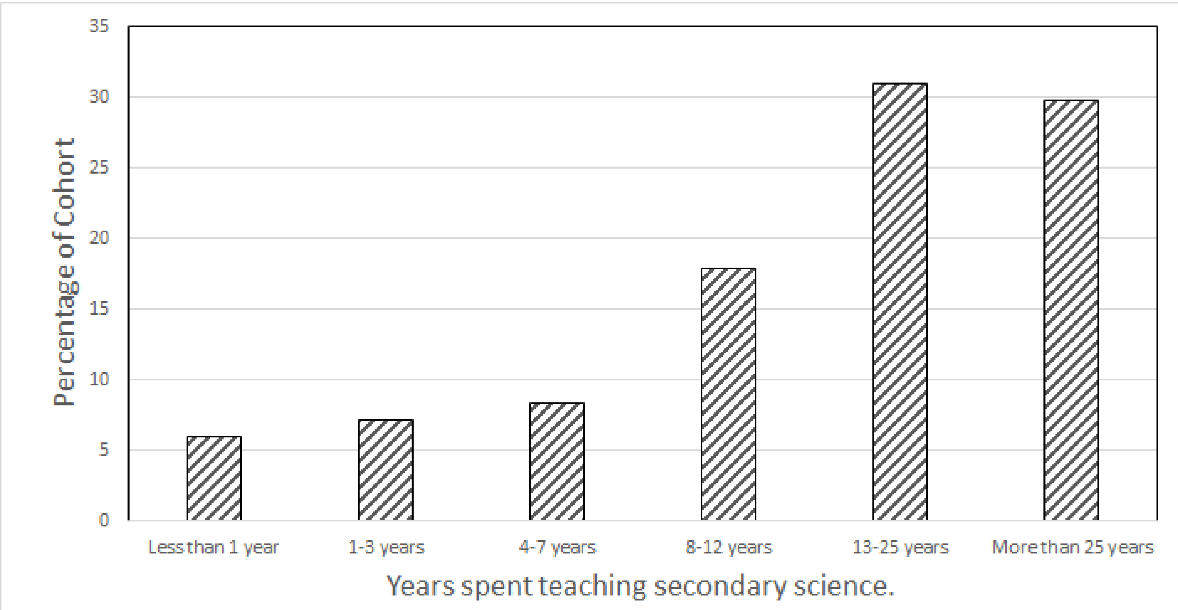

Figure 3: Years spent teaching overall.

The Diploma of Education (58%) was the most common educational qualification, with a Bachelor of Education (20%) being the second most common. Some had a Master of Education (8%) degree, while one held a Master of Teaching and one a PhD. The vast majority (98%) were qualified to teach junior science (Grades 7-10). In the senior science areas, the majority were qualified to teach Chemistry (85%), Physics (71%), and Biology (69%) with lower rates for the Earth and Environmental Science (43%) and Senior Multi-Strand Science (40%) courses.

The median ordinal category of class size reported for Grade 7 science classes was 26-30, for Grade 8 to Grade 10 it was 21-25, Grade 11 it was 11-15 and for Grade 12 was 1-10 students. In 41% of the schools, teachers reported that only 10-20% of students pick physics to study in Grades 11 and 12. Perhaps more worryingly, less than 10% of students picked physics in 41% of schools. In contrast, 16% of teachers reported that in *their school* the proportion of students who studied physics was 20-30% and only one school (2%) reported a rate above this. One is left to conclude that the uptake of physics in the senior high school is low.

Students

The student sample is comprised of students who have undertaken the survey either in the paper-based or electronic forms in the Space to Grow project until the end of 2012. While data were collected from students in other grade levels, we focus primarily on the responses from students in Grade 10 (N=1770) and Grade 9 (N=742), the two years immediately prior to students making their subjects choices for senior high school. These students can be described as an opportunity sample due to the nature of the research being embedded within a project bounded by educational jurisdictions which involved intact class groups taught by a teacher who either volunteered to become involved or who was nominated by the school.

Instruments Used

In this research, two modified versions of the Secondary School Science Questionnaire (SSSQ; Goodrum et al., 2001) were used. These instruments have been previously used to examine student attitudes and perceptions of school science over the course of an innovation (Danaia 2006, Fitzgerald et al. 2016) and over time (Danaia et al., 2013). The first instrument is a slightly modified version of the original SSSQ as reported in Danaia (et al., 2017). The second, termed the *Teacher Secondary School Science Questionnaire* (TSSSQ), is a modified form of the student-SSSQ survey which is used to probe the teacher's perceptions of the school science that happens in their classroom. It closely mirrors the student survey. That is to say, the items are phrased to reflect the role of the respondent: for the students, the stem was “In my science classes, my teacher...” and the teacher responded to “In this science class, I...” and the remainder of the items were identical. The teacher questionnaire was constructed to allow direct comparisons of the perceptions of teachers and students. Beyond the Likert-scale items, teachers also provided demographic information on age, employment, scientific and educational background, and their qualifications as well as their broader opinions on schools, school science and their roles within science in the community.

The results in the individual items for students and teachers are presented to allow comparisons of each individual item on the survey rather than try to amalgamate the 40 items into scales using an exploratory or confirmatory factor analysis. There are four reasons for adopting this approach. First, we are not looking for any latent variables that drive students’ or teachers’ responses to the items. Second, we are not looking for any relations amongst such latent variables; we are looking solely at the raw difference in *perception* between teachers and students. Third, while presented in sets of related items, which we have also replicated here, the original source of the questionnaire (Goodrum et al., 2001) presented no theoretical basis for any underlying factor structure. Consequently, we adopt the same approach. Fourth, rather than the traditional "Strongly Agree through Strongly Disagree" Likert scales, all of the SSSQ items actually represent *perceptions* of *rates of particular experiences* in the science classroom. This makes it more difficult to create “scales” that reflect the “optimum value” for any given experience. For example, a statement in the teacher questionnaire is "Students find science lessons challenging" may not be at the top end of the ordinal scale (i.e. Almost always), but may be somewhere in the middle (i.e. "Often"). This item is a description of that teacher’s experience with that particular class in that particular year. While we can, and do, make broad assumptions about the direction of 'positivity' for some of the ordinal items, there is little information on what the true *optimal* answer for any item should be. Hence, any factor structure that creates reliable scales may act to muddy the general picture rather than provide more clarity.

Overall Mean Comparison Between Teacher and Student Perception

In this first section of the results, we compare the distributions of responses provided by teachers and students for each individual SSSQ item. These comparisons represent the convergence or divergence between the teacher and student population perceptions of their science classes overall. Table 1 presents the cross-tabulation, the Chi-Square statistic and the calculated p-value. Given that 39 Chi-squares are being computed, it is not reasonable to accept a p-value of 0.05 below which a significant difference in the pattern of responses of students and teachers can be claimed (Simes 1986). We thus employ a modified-Bonferroni correction to the p-value using the average inter-item correlation of 0.247. The new p-value below which significance is indicated is 0.0031.

The individual items are grouped together into the same groups originally presented by Goodrum et al. (2001). The population response of the teachers is presented together with the population response by students. A chi-square statistic is computed for each item and the modified Bonferroni correction applied to the p-value obtained from the cross-tabulation. Only those items with a p-value that falls below the computed value of 0.0031 are highlighted as significant.

This first set of items (1-9), shown in table 1, deals with the types of learning activities experienced in the classroom. All of the items, apart from Item 3,'I work out explanations in science with my friends', show statistically significant different patterns of responses between students and teachers. In addition, all of the items except for item 5, 'read a science textbook' are biased towards the teachers painting a more favourable picture and that these events happen frequently as experienced by the students. The results for item 5 are somewhat hard to interpret. In the original Goodrum et al. (2001) paper the distribution was peaked at each extreme (Never and Always), as were the dataset used in Danaia et al. (2013). In our data, the student data is effectively evenly spread across the whole range, while the teacher’s responses peak at about once per week.

Item	Population	% Response *Never (%)*	*Once a Term (%)*	*About Once a Month (%)*	*About Once a week (%)*	*Nearly every lesson (%)*	*Sig p.*
In my science class							
1. I copy notes the teacher gives me	Students	2.6	2.7	7.4	21.5	65.7	**5.2E-19**
	Teachers	3.6	7.2	13.3	54.2	21.7	**
2. I work out explanations in science on my own	Students	5.7	8.5	23.4	39.2	23.2	**3.2E-05**
	Teachers	1.2	0.0	16.9	42.2	39.8	*
3. I work out explanations in science with my friends	Students	4.9	5.5	16.1	38.1	35.5	3.4E-02
	Teachers	1.2	0.0	14.5	41.0	43.4	ns
4. I have opportunities to explain my ideas	Students	9.1	10.0	23.0	29.2	28.7	**4.2E-10**
	Teachers	1.2	3.6	4.8	36.1	54.2	**
5. I read a science textbook	Students	20.2	16.5	20.8	22.8	19.6	**6.1E-07**
	Teachers	6.0	10.8	28.9	42.2	12.0	**
6. We have class discussions	Students	5.8	6.0	14.0	27.0	47.1	**2.0E-04**
	Teachers	1.2	0.0	6.0	26.5	66.3	*
7. We do our work in groups	Students	5.5	9.3	28.0	36.6	20.6	**7.3E-10**
	Teachers	1.2	2.4	4.8	56.6	34.9	**
In science, we							
8. Investigate to see if our ideas are right	Students	10.4	12.8	27.2	31.9	17.6	**5.3E-04**
	Teachers	2.4	15.7	42.2	31.3	8.4	*
My science teacher							
9. Lets us choose our own topics to investigate	Students	47.4	25.2	16.9	7.3	3.3	**1.1E-16**
	Teachers	8.4	55.4	30.1	3.6	2.4	**

Table 1: Learning activities – dealing with content in science in the secondary school

The next set of items (10-12), shown in table 2, deals with practical work in the school science classroom. One could argue that a teacher demonstrating experiments is better than doing no experiments at all, but this is, in turn, worse than the students undertaking experiments themselves via following instructions. It is likely that there is a confound variable where the teacher thinks that experimental work is undertaken more often than the students and perhaps takes into account all of the opportunities for experimental work leading to the teachers recording a more frequent response than the students who have a different set of criteria about what constitutes "experimental work". Nonetheless, and with this caveat in mind, these results can be interpreted as the teachers' perception is that there is a higher rate of experimental work being done overall than the students perceive.

Item		Population	% Response Never (%)	Once a Term (%)	About Once a Month (%)	About Once a week (%)	Nearly every lesson (%)	Sig p.
In my science class								
10. I watch the teacher do an experiment		Students	7.9	14.4	32.5	29.7	15.5	**1.4E-04**
		Teachers	2.4	7.2	31.3	49.4	9.6	*
11. We do experiments by following instructions		Students	4.2	6.1	19.5	38.5	31.7	**1.8E-05**
		Teachers	2.4	0.0	6.0	59.0	32.5	*
12. We plan and do our own experiments		Students	28.2	25.0	23.3	15.6	7.9	**1.3E-10**
		Teachers	6.0	16.9	49.4	21.7	6.0	**

Table 2: Learning activities --- practical work in science in the secondary school

Items 13-16, shown in table 3, probe what teachers and students perceive about the nature of school science in terms of how often students need to undertake deeper thinking about the science itself. For all of the items, it is clear that the teachers have a much more positive view of the depth of thinking required in the science classroom than do the students.

Item		Population	% Response Almost Never (%)	Sometimes (%)	Often (%)	Very Often (%)	Almost Always (%)	Sig p.
In science we need to be able to								
13. Think and ask questions		Students	5.2	13.4	25.6	25.7	30.1	**2.3E-09**
		Teachers	1.2	0.0	12.0	31.3	55.4	**
14. Remember lots of facts		Students	5.4	13.8	25.9	28.6	26.3	**1.0E-15**
		Teachers	4.8	38.6	37.3	16.9	2.4	**
15. Understand and explain science ideas		Students	5.3	14.4	25.5	29.4	25.5	**2.1E-04**
		Teachers	1.2	1.2	24.1	37.3	36.1	*
16. Recognise science in the world around us		Students	6.3	15.2	25.4	26.8	26.3	**5.8E-08**
		Teachers	1.2	1.2	15.7	34.9	47.0	**

Table 3: What students need to be able to do in science in secondary school

Items 17-25, shown in table 4, represent a variety of ideas surrounding the quality of science teaching. It is clear that teachers perceive the quality of feedback and guidance they give to happen more frequently than the students. Two exceptions to this are item 21, “We have enough time to think about what we are doing” where students seem to think they more frequently have enough time than the teachers and item 23, “makes it clear what we have to do to get good marks” which is not statistically significant. The high stakes standardised testing environment of modern schooling possibility is the explanation for why teachers and students both have fairly accurate assessments of the frequency of being told how to get good marks. It is not clear why students think they have more time to think about what they are doing than the teachers, perhaps due to the teacher’s perception of (their own precious) time more than an accurate assessment.

Item	Population	% Response Never (%)	Once a Term (%)	About Once a Month (%)	About Once a week (%)	Nearly every lesson (%)	Sig p.
My science teacher							
17. tells me how to improve my work	Students	10.1	15.6	25.8	29.8	18.7	**2.0E-15**
	Teachers	1.2	3.6	4.8	48.2	42.2	**
18. gives us quizzes that we mark to see how we are going	Students	16.5	25.4	36.6	16.1	5.3	**3.3E-10**
	Teachers	8.4	4.8	44.6	37.3	4.8	**
19. talks to me about how I am getting on in science	Students	18.7	25.0	28.5	19.5	8.3	**1.5E-26**
	Teachers	1.2	2.4	19.3	53.0	24.1	**
20. shows us how new work relates to what we have already done	Students	8.7	9.0	21.5	33.2	27.6	**1.2E-15**
	Teachers	1.2	0.0	8.4	25.3	65.1	**
During science class							
21. We have enough time to think about what we are doing	Students	7.5	22.4	31.8	24.7	13.6	**9.6E-04**
	Teachers	2.4	16.9	47.0	28.9	4.8	*
		Almost Never (%)	*Sometimes (%)*	*Often (%)*	*Very Often (%)*	*Almost Always (%)*	*Sig p.*
My science teacher							
22. marks our work and gives it back quickly	Students	9.6	16.2	28.9	33.2	12.2	**9.8E-08**
	Teachers	1.2	2.4	50.6	38.6	7.2	**
23. makes it clear what we have to do to get good marks	Students	5.3	8.4	18.2	33.5	34.6	4.5E-02
	Teachers	1.2	2.4	16.9	41.0	38.6	ns
24. Uses language that is easy to understand	Students	5.6	6.2	15.2	27.3	45.6	**3.8E-14**
	Teachers	1.2	0.0	2.4	9.6	86.7	**
25. Takes notice of students' ideas	Students	7.0	9.5	17.3	29.2	37.1	**3.8E-13**
	Teachers	1.2	0.0	2.4	22.9	73.5	**

Table 4: Teacher feedback and guidance in science in the secondary school

The pattern of responses for the next two items (26-27), shown in table 5, are both statistically significant. It is not clear, however, whether more frequent use of computers and the internet can be necessarily regarded as a good thing. Nonetheless, it is clear that teachers reported a significantly more frequent use of computers and the internet in science. In the original Goodrum et al. (2001) report, the frequency of use were very low. In the intervening timespan, however, computer use is the classroom has become much more common.

Item		Population	% Response Never (%)	Once a Term (%)	About Once a Month (%)	About Once a week (%)	Nearly every lesson (%)	Sig p.
In science, we								
26. Use computers to do		Students	6.5	14.3	34.4	29.4	15.4	**2.4E-06**
our science work		Teachers	2.4	2.4	26.5	51.8	16.9	**
27. Look for information on		Students	7.6	12.6	33.5	32.5	13.9	**1.5E-04**
the Internet at school		Teachers	1.2	4.8	27.7	51.8	14.5	*

Table 5: Computer use in science in the secondary school

Items 28-30, shown in table 6, probe students' perceptions of their enjoyment of, and curiosity in, science classrooms. In general, teachers perceive students to be less bored and more excited than the students report. It is very clear that teachers vastly positively overestimate how excited and/or bored students are in the science classroom. However for item 29, "I am curious about the science we do", the students are fairly evenly spread across the range, some are always curious and some are never curious in equal parts, whereas teachers seem to largely interpret their students as often being curious.

Item		Population	% Response Almost Never (%)	Sometimes (%)	Often (%)	Very Often (%)	Almost Always (%)	Sig p.
During science class								
28. I get excited about		Students	21.7	34.8	21.0	12.6	9.8	**1.1E-13**
what we do		Teachers	2.4	24.1	38.6	31.3	3.6	**
29. I am curious about the		Students	14.3	26.1	23.4	19.8	16.5	**4.6E-09**
science we do		Teachers	2.4	20.5	47.0	25.3	4.8	**
30. I am bored		Students	17.1	38.4	14.4	12.6	17.4	**2.7E-16**
		Teachers	6.0	79.5	13.3	1.2	0.0	**

Table 6: Enjoyment and curiosity in science in the secondary school

Items 31-34, shown in table 7, attempt to measure the extent to which science is perceived to be difficult and challenging. It appears that teachers perceive that students find science to be much harder than students perceive. Students tend to feel that they rarely misunderstand the science or find it too hard. They more frequently perceive it as too easy, in contrast to teacher perceptions. The comparative distribution between teachers and students on the question of the level of challenge is more evenly spread and only borderline statistically significant.

In the final set of items (35-39), shown in table 8, the relevance of school science to the students' life is probed. Teacher's perceived that the science they teach is more relevant to students' lives than the students do. This is not unexpected.

Item	Population	% Response Almost Never (%)	Sometimes (%)	Often (%)	Very Often (%)	Almost Always (%)	Sig p.
During science class							
31. I don't understand the science we do	Students	25.6	44.8	14.2	8.1	7.3	**1.1E-08**
	Teachers	7.2	73.5	16.9	1.2	1.2	**
32. I find science too easy	Students	34.3	38.8	16.0	6.5	4.4	**7.2E-05**
	Teachers	39.8	54.2	2.4	3.6	0.0	**
33. I find science challenging	Students	7.5	32.8	26.8	20.4	12.5	**1.8E-03**
	Teachers	2.4	26.5	37.3	28.9	4.8	ns
34. I think science is too hard	Students	32.8	34.5	15.3	7.8	9.6	**1.6E-10**
	Teachers	8.4	48.2	22.9	19.3	1.2	**

Table 7: Perceived difficulty and challenge of science in the secondary school

Item	Population	% Response Almost Never (%)	Sometimes (%)	Often (%)	Very Often (%)	Almost Always (%)	Sig p.
The science we learn at school							
35. is relevant to my future	Students	24.5	33.0	19.9	12.5	10.1	**6.7E-14**
	Teachers	1.2	21.7	44.6	24.1	8.4	**
36. is useful in everyday life	Students	22.4	38.2	20.5	11.3	7.6	**1.5E-11**
	Teachers	1.2	26.5	43.4	20.5	8.4	**
37. deals with things I am concerned about	Students	27.5	35.9	20.1	10.0	6.5	**9.2E-10**
	Teachers	2.4	37.3	39.8	16.9	3.6	**
38. Helps me make decisions about my health	Students	27.4	33.7	20.3	12.0	6.7	**3.8E-06**
	Teachers	6.0	38.6	32.5	19.3	3.6	**
39. Helps me understand environmental issues	Students	12.0	26.3	27.8	21.6	12.3	**4.4E-04**
	Teachers	4.8	22.9	43.4	25.3	3.6	*

Table 8: Perceived relevance of science in the secondary school

To more directly illustrate the broad differences, Figure 4 graphically demonstrates this difference in students' (black) and teachers' (grey/hatched) responses showing the mean ordinal score for each item. Here the mean scores for each item are presented as an overlaid horizontal bar chart. For all of the statistically significant different patterns of responses, teachers express a more positively skewed view of their in-class practices compared with those expressed by the students. The three exceptions to this pattern are Item 1 'students copy notes in class', Item 14 'remember lots of facts' and Item 30 'are bored' where students views are more positively skewed. It may be observed that in these latter three items, if they were to be recoded in the reverse direction, the same pattern would persist and one could claim that teachers paint a more positive picture of their classroom than do their students.

Teacher and Student Aggregate Data

In the previous section we concentrated on comparing the responses of teachers and students for the entire sample. In this section we examine the same items but break them down into paired student and teacher groups in which 64 of the 86 teachers were able to be reliably matched to their students. Each student was required to name their teacher during the survey solely for matching purposes to control for cases where there were multiple simultaneous classes at a single school. After matching this identifiable information was discarded. Thus, the student data were aggregated to produce a mean and standard deviation for each item before the student data were merged and matched for each teacher with their discrete ordinal response. Thus, each teacher’s ordinal response is able to be compared to the mean value of the students' ordinal responses in their class.

For each item, the teachers were grouped into batches representing a given ordinal response. For instance, the teachers were sorted into those teachers who said "Almost Never", "Sometimes", "Often", "Very Often" and "Almost Always'. The mean responses of each of the student groups corresponding to each teacher were then further averaged to represent the average response of student groups to teachers who responded with that particular ordinal response (e.g. "Sometimes or Often") choice.

One-way ANOVAs were performed to determine the statistical significance of each relation. Taking the previously calculated modified Bonferonni corrected significance value of 0.0031, none of the relations were found to be statistically significant. As there are a lot of items, with a lot of teachers, a lot of students, and a lot of relations, a simple table cannot hold all of this information in any simple manner. To represent the data, we have created a graph for each item that holds the multiple dimensions and adds value with a number of calibration lines. We present a sample of one of these graphs, which represents one of the most clearly borderline significance, for explanation purposes in Figure 5. The entire sample of item represented by smaller graphs are presented in Figure 6 and Figure 7.

In Figure 5, the x-axis represents the ordinal teacher response, while the y-axis represents the mean values of the student groups for all teachers who responded with that response. The error bars on the points represent the standard deviation of the student group mean responses. If there are no error bars, such as in the 'Once a term or less' category in Figure 5, it means there was only a single teacher who responded in that manner and hence there is no variance in response. The diagonal line represents what would be expected for perfect agreement between the teachers and student groups. This diagonal line is never likely to be achieved unless in the unlikely event that all students in all groups answered with the same response as the teacher.

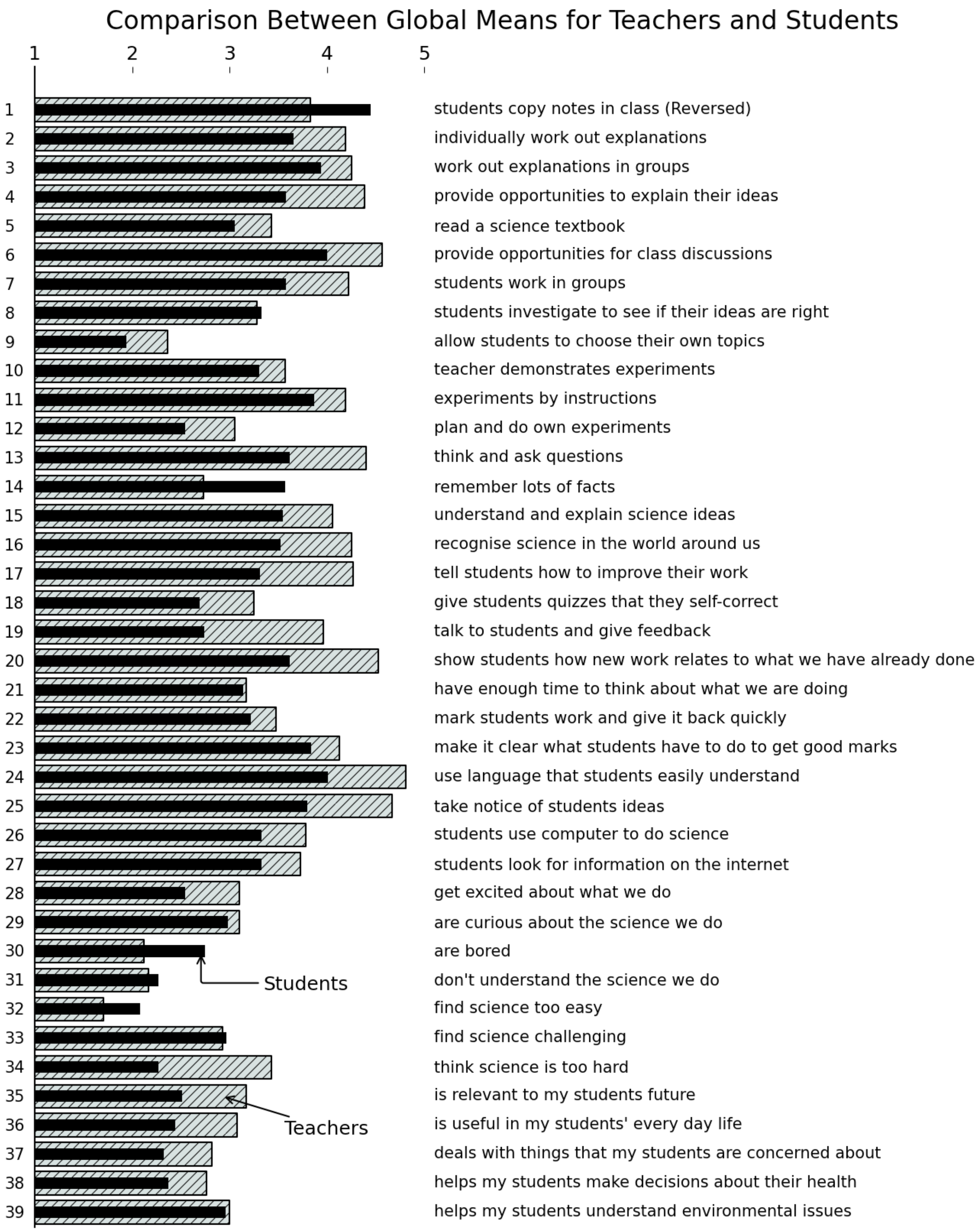

Figure 4: Comparison of teacher and student means.

The solid line represents the global mean score for students, while the larger hatched line represents the global mean score for teachers.

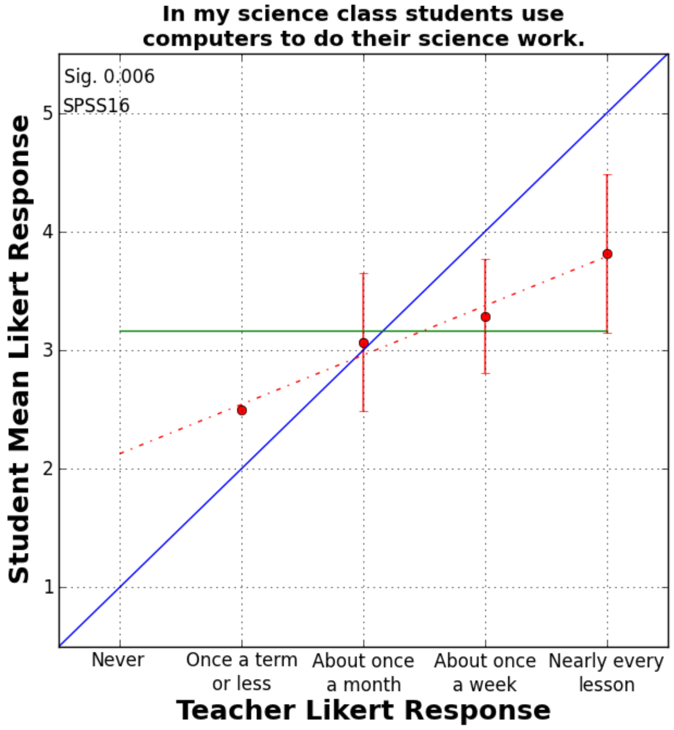

Figure 5: Closeup of Example Figure

If we are searching for correlations, then what we are looking for in the pattern of responses is a definite slope in the data of the student responses compared to the teacher response. If the slope in the student responses is positive (in the same direction tending higher to the right) and statistically significant, it means the students relatively agree with the teachers. That is to say, the more the teacher thinks X about a class and the more the students also think X, the more alike their perceptions of what is happening in that particular class. If the slope in the student-response line is negative (in the opposite direction tending lower to the right) and statistically significant, it means the more the teacher thinks X about a class, the *less* the students think X.

While it must be remembered that Figure 5, just like ALL other figures are technically statistically insignificant, a slope can be identified in the dashed line fit between the points on the graph. This slope was fit with a traditional non-weighted least square linear fit to the data. The main reason for insignificance is due mainly to the very large standard deviation in the student groups' responses.

In the graph there is another line, the solid horiztonal line. This represents what we would assume if there were zero dependency in the student responses upon the teacher responses. This is a representation of the null hypothesis case that all of the charts statistically agree with. It is the case for the charts provided in Figure 6 and 7 that there is minimal visible difference and no statistical difference between the best dotted line fit (assuming a difference) and the best solid line fit (assuming the null hypothesis). This leads us to the conclusion that the perceptions of teachers of classroom activity on all probed items from the SSSQ have little or no relation to the perception of the students of the activity in their classroom.

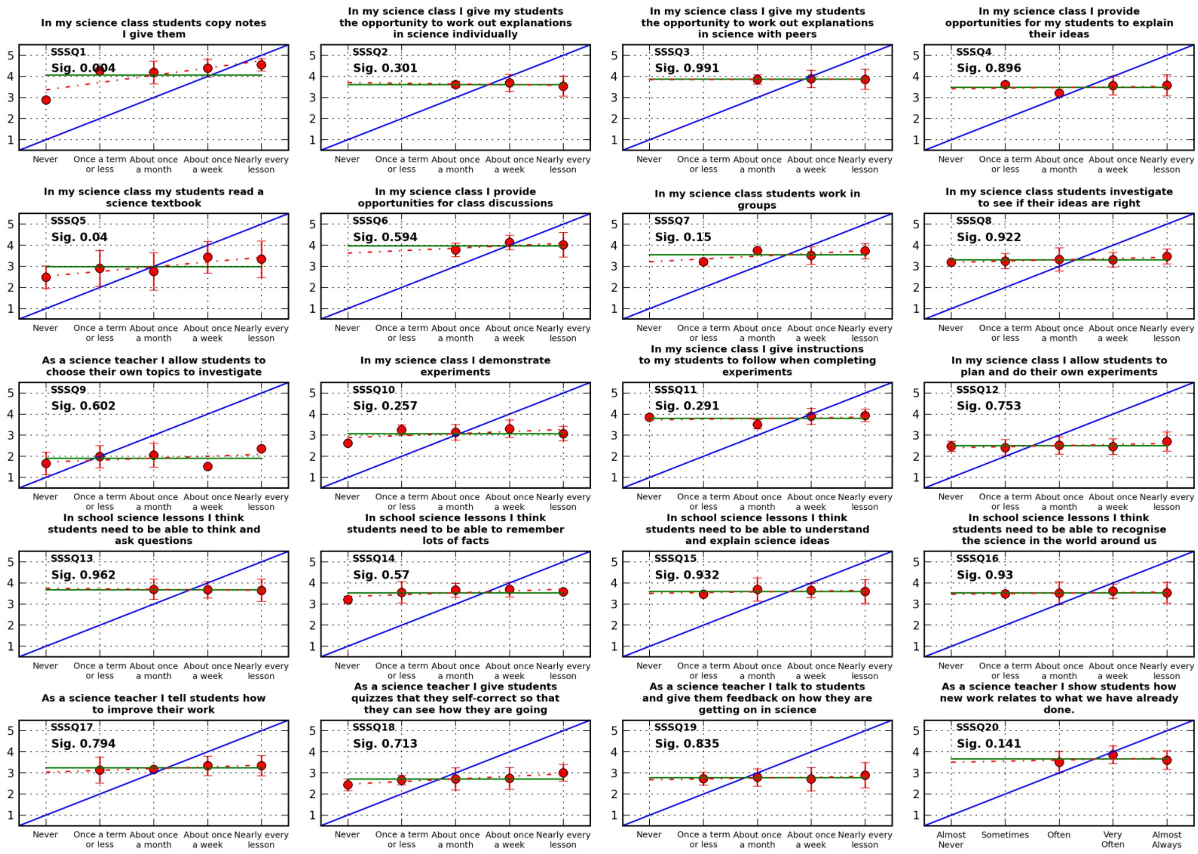

Figure 6: Comparison of teachers perceptions to students' perceptions for first set of 20 items on the SSSQ.

Discussion

This paper has compared the perceptions of students and teachers of their science lessons on the same metrics via two methods. First, the responses of the entire student and teacher sample are compared using Chi-square analysis. By doing so, we found statistically significant differences in the patterns of responses of teachers and students on most of the items in the SSSQ survey. For those with significant differences, most are interpreted as the teacher having a more positive view of that aspect of their classroom or of their teaching than do the students, although there are a number of items with less clear interpretations.

The diagrams and tables above present an overall picture of these differences. Examining the results deeper, there can be seen strong differences in specific areas. For example, one of the most striking examples is the rate at which students perceive that they are simply copying down notes. Students report 65% of the time that they copy down notes provided nearly every lesson compared to the 22% reported by teachers. 90% of teachers report that students have opportunities to explain their ideas about once a week or nearly every lesson compared to 58% of students. 47% of students report that they never have opportunities to choose their own topics to investigate compared to 8% of teachers.

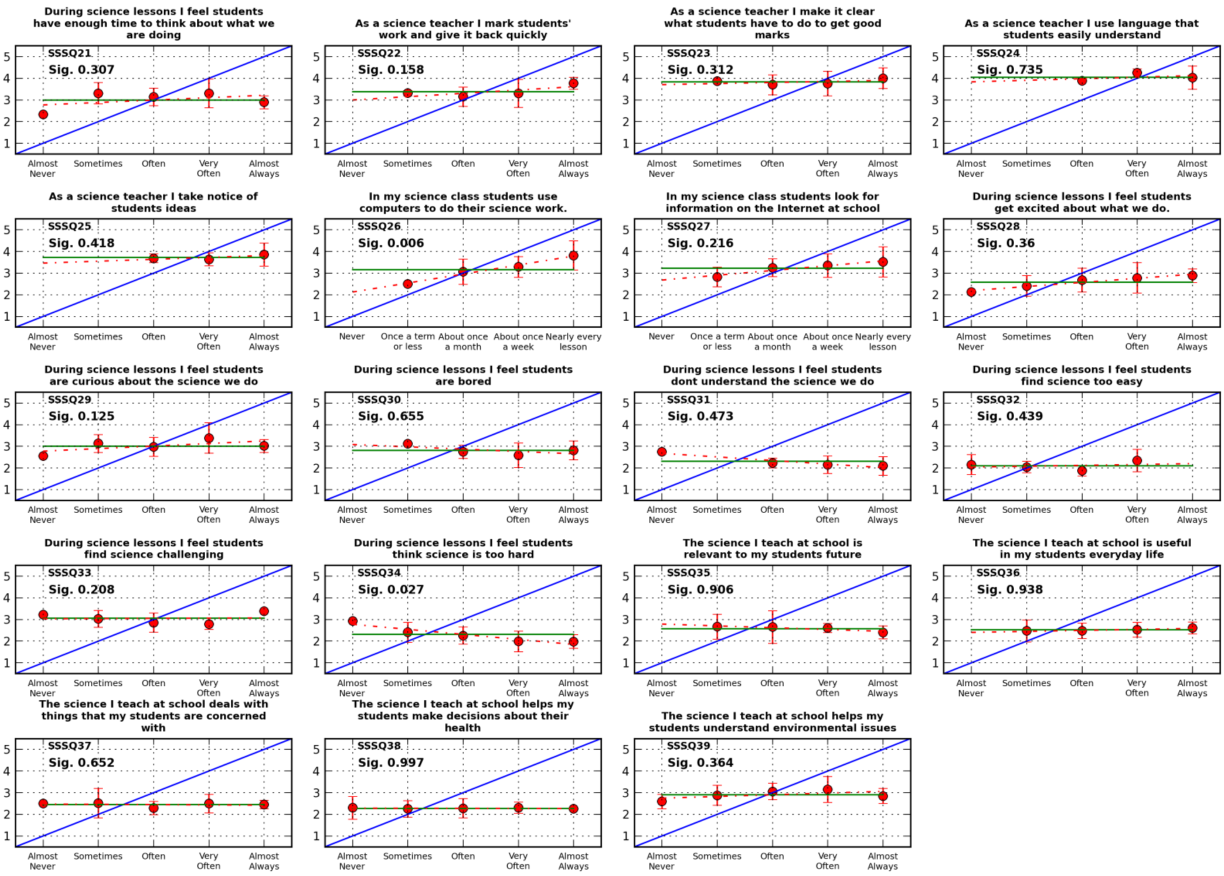

Figure 7: Comparison of teachers' perceptions to students' perceptions for second set of 19 items on the SSSQ.

90% of teachers also claim that they provide feedback, once a week or nearly every lesson, on how to improve student work whereas 48% of students report these rates. 44% of students report being bored often, very often or almost always whereas only 14% of teachers perceive this to be the case. There are numerous cases of stark differential perceptions within the first analysis within this paper. These findings on rates of student responses are broadly consistent with Danaia et al. (2013) and the various earlier reports (Goodrum et al. 2001, Danaia 2006, Goodrum & Rennie 2007, Goodrum et al. 2012). This is the first time that the student perceptions have been able to be compared directly to teachers' perceptions.

Overall, looking at the results of the second analysis, there also appears to be no statistically significant relationship between what an individual teacher perceives and what their matched students perceive. Regardless of any response by a teacher, the students' responses hover very closely around a global mean. One might assume that this implies that it is students who provide the most realistic appraisal of what is occurring in their classroom, however we cannot be sure as no external objective measure has been applied in order to identify what the perceptions actually should be. Also, whether or not these perceptions represent actual differences in classroom behaviours rather than a simple difference in perception would require an observational study.

Implications of the significant differences between student and teacher perceptions remain unclear. However, it is clear from the results in this study that 1) teachers overall perceive that which occurs in their classroom in a more positive light and 2) students in general seem to perceive their science classrooms similarly regardless of the perceptions of their teachers. This has a variety of impacts on the nature of school science education as well as teacher education and evaluation.

It is implied that there is little point in solely using the teachers to evaluate an educational approach or intervention. On quantitative measures such as those presented in this paper, it seems that teachers will generally paint a much more positive picture than their students will. Hence, the final evaluation of any educational endeavour needs to be undertaken at the level of both the teachers and students. This also means that teachers are perhaps under the impression that their classrooms are running in a generally more positive fashion than they actually are, leading to a lack, or an underestimate, of any required remediation of in-class practices. This may be difficult for teachers who are already generally pushed to the limits of their resources (Fitzgerald et al. 2019), but in reality it is probably more a function of the situational context that the teacher has to work within. It is true that is has been reported that student perceptions and perspectives are rarely brought into consideration (Osborne & Collins 2000)

The SSSQ is a useful research tool to plot changes in student perception over small time scales (Fitzgerald et al. 2016), long time scales (Danaia et al. 2013) as well as comparing the difference between student and teacher perceptions in their classrooms as a whole. As yet, however, the SSSQ, similarly to the QTI tool (Wubbels et al., 1985), it has yet to be adequately tested as a diagnostic tool for improvement for individual teachers in their science classroom. It is not clear that showing an individual teacher their convergence or divergence in perceptions with their students may cause anything other than an increase in stress on the part of the teacher when a large proportion of their current practice is driven by their context and school situation. Further research is also required to explore whether the differences in perceptions between teachers and students found by this study and previous studies are due to the teachers being overly positive or the students being overly negative compared to the true observed rates, such as rates of copying notes or choosing topics, actually seen in the classroom.

The most general conclusion that can be taken from this paper is that it is the students, and not their teachers, who are likely to provide the most realistic appraisal of what is occurring in their classrooms. Decisions about what occurs in the classroom are usually undertaken by their teachers and outside ‘experts’ rather than through listening to the student voice (Osborne & Collins 2000). The most efficient way to get a good picture of multiple science classrooms within any limited educational context, such as a school or jurisdiction, is to talk to the teachers directly. It must be kept in mind though that the person asking the questions may be given a rosier picture (even if the picture is already dark) than what would be elicited from the students. The students, and their achievement and motivation, in any educational endeavour are, after all, the ultimate sources of evaluation in which teachers can only be at best a vague proxy.

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