



***What Students Think and How They Really Perform
in Chemistry***

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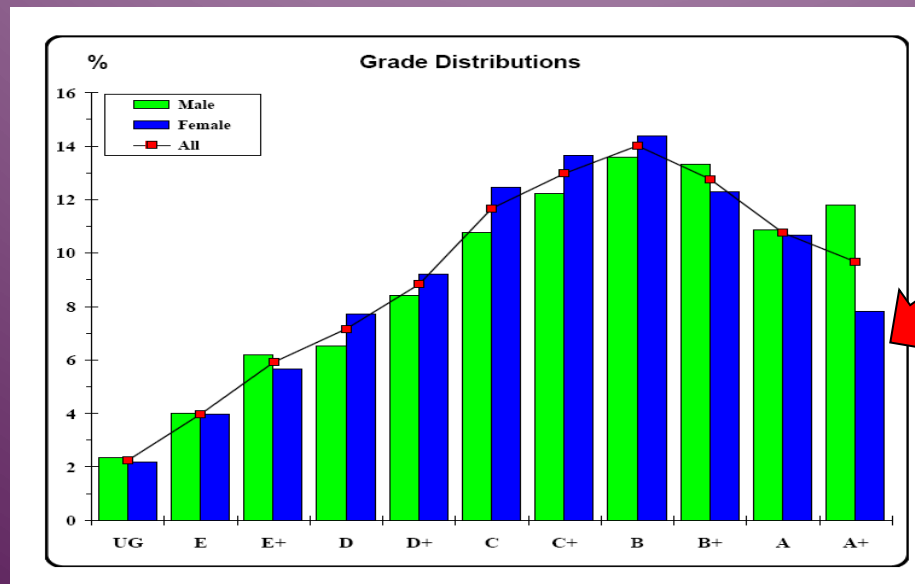
Some Background

- An experienced chemistry teacher of over 30 years.
- Year 12 chemistry is a subject in the final year of secondary school.
- The examination comprised of two 1 ½ hour examinations. One mid year and the other at the end of the year.
- Each examination is independent and consists of 20 MCQ and about 8 SAQ.
- The combined score contributes to the subject score and finally to their cumulative score.
- University selection is largely based on this score. Very high stakes.

Why?

- Observed differences in performance on two examinations.
- Gender differences in performance.
 - Situation on semester 2 examination very similar.
 - Nearly all differences at A+ grade were significant ($p < 0.001$) for 2008 to 2012.

Figure 1: Grade distributions for the 2010 Chemistry Examination¹



Issues in initial study

- Why were male and female students performing differently?
- What impact did question style and content have on performance?
- How did students perceive question type content and performance?

Research Questions

- Do students have a preference for the type of question style in terms of
 - Multiple-choice or short-answer in general terms,
 - With respect to whether the question is assessing recall or application,
 - Gender.

Does student performance correlate with student perceptions about chemistry testing?



Study

1. Conduction of trial tests with 192 (184 useful) secondary students from four schools.
2. ANOVA analysis of trial tests.
3. Rasch analysis of trial papers-including gender difference.
4. Conduction of interviews with a sample drawn from the 192 participating students.



Results: Trial tests

- 184 students approx 50:50 male female.
- 4 tests. Two based on predominately recall content and two application.
- Tests were paired. One was all multiple-choice and the other all short-answer.
- Questions on each pair were intended to cover similar content.



Trial tests

- Grade distribution showed a similar pattern to that of the SUE examinations.

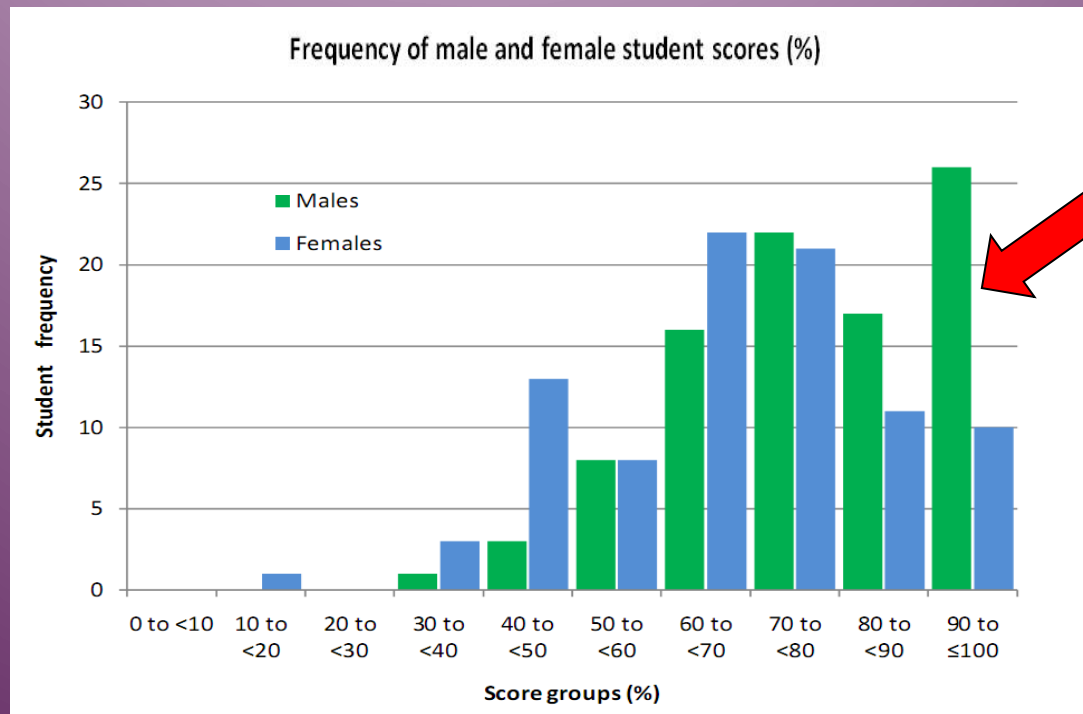


Figure 2: Distribution of male and female scores in the Chemistry trial tests



Trial test summary

1. Male students (mean: 78.3%) outperformed female students (68.6%).
2. Students performed better on multiple choice than on short answer questions.
3. Students performed better on recall questions than on application questions.

Rasch analysis-gender difference

- In each comparison the male mean score was higher than the female mean score.
- However, the gender difference analysis showed that there was little actual difference in performance for male and female students of equal ability.
- This outcome was demonstrated in each comparison for gender DIF analysis
 - Short-answer questions
 - Multiple-choice questions
 - Recall questions
 - Application questions.

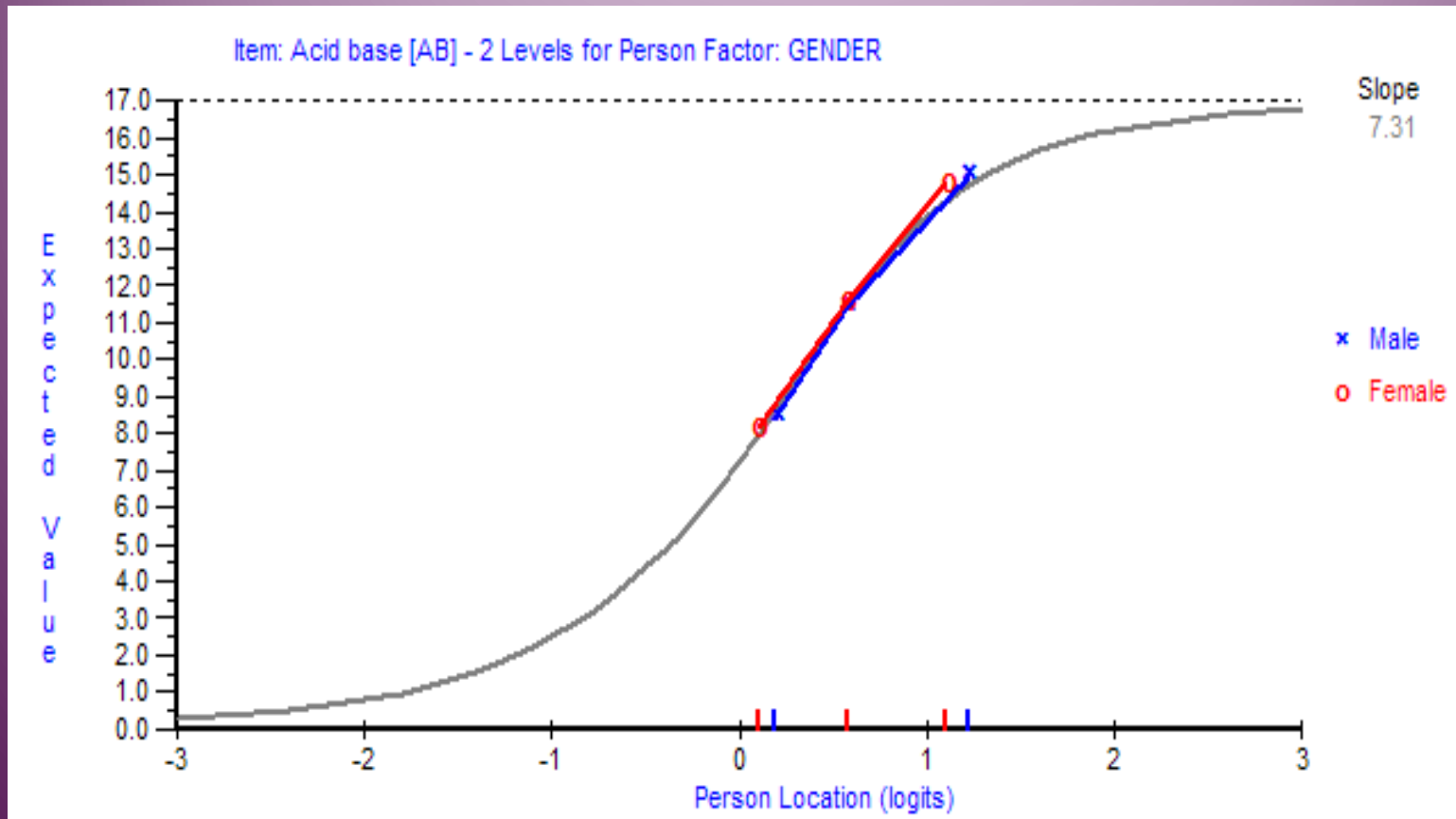


Figure 3: Recall questions: showing gender difference against expected score and student ability



Conclusion

- It seems that more high ability males are choosing Chemistry than are high ability females.
- The high ability females appear to be choosing subjects other than Chemistry.
- In terms of performance there was little to separate males and females of equal ability.

Literature: Gender

- Male students usually outperform female students in assessments in the areas of mathematics and science.
- Difference is more pronounced in physics and chemistry than in biology and psychology.
- Short-answer questions tended to favour female students whereas multiple-choice favoured male students.
- In terms of higher order questions, males tended to outperform females regardless of the question type.



Literature: Motivation

- Unsurprisingly motivation is a key determinant of success.
- Male students have typically favoured choosing more “traditional” sciences (e.g. Chemistry and Physics).
- Male students tend to have a more positive outlook of potential success in these traditional sciences.
- Results have usually shown greater achievement levels by males compared to females in these subjects.
However, in recent times the gap is narrowing.

The interviews

- 59 students were interviewed (from 192)
- Interview schedule was standardised.
- A small random sample of students were reinterviewed a few weeks later.
- Interview schedule is in the paper.
- Responses were coded as being positive or negative to the question asked.

Interview results

- A series of questions elicited responses as to preferences for certain types of questions and question content.

Table 1: Responses to Research Question 1 (n = 59)

Question preference combination	Males	Females	Totals
Recall: as MC and Application: as MC	6	7	13
Recall: as MC and Application: as SA	19	22	41
Recall: as SA and Application: as MC	1	0	1
Recall: as SA and Application: as SA	1	3	4
Totals	27	29	59

- Surprisingly few differences between males and females.
- MCQ preferred method for recall type questions and SA for application.

- A follow up question was asked.
- *“If a test was to be either all multiple-choice or all short-answer which would you generally prefer to do regardless of the test topic?”*

Table 2: Preferences of Students for Question Type (n=100)

Group	Percentage who favoured multiple-choice	Percentage who favoured short-answer
Males	66	34
Females	54	46

- *The preference of MCQ over SA with males compared to females became obvious. ($p < 0.05$)*

Summary student responses

- **Table 3: Advantages and Disadvantages of Multiple-choice questions**

Advantages	Disadvantages
Possible to eliminate or narrow down response.	Can be confusing or tricky with good options
Can work backwards from the answers	Can appear to have more than one correct answer
Prompting of answer from given options.	Penalized if you make a silly mistake or small error
Checking answer against options	Can't show your working out
Can guess the answer if it can't be worked out	Questions seemed designed to trick students
Usually easier questions	
Quicker to do	

- **Table 4: Advantages and Disadvantages of Short-answer questions**

Advantages	Disadvantages
Proves that the student really knows the work	Don't have an opportunity to check answer against any given options.
Can get marks for partially correct answers	If you don't know what to do you can't attempt the question at all.
Worth more marks	Usually worth a lot of marks each
Can see where you went wrong	Usually harder questions
	No prompts from the question like multiple-choice

MCQ Student Responses

- MCQ advantage:
- *“Multiple-choice only. It is much easier and reassuring. If you don’t come up with the right answer it forces you to look over your working and then try to work out where you have gone wrong. This cannot happen in short-answer questions, as you can’t be sure you are right”.*
- *“Sometimes because the answer is on the page you just need to select it.”*
- MCQ disadvantage:
 - *“You don’t get any marks if you do the working out method partially correct but get the wrong answer.”*

SA Student responses

- SA advantages:

- *Short-answer, helps students show their working out step by step for future exams, and rewards points for you step, rather than lose all of the marks. Also once you finished the test, you can look at what went wrong in your steps thus correcting the mistakes. Also you can correct your method of approach. Also can help your vocabulary by writing.”*

- SA disadvantages:

- *“Yes, if you don’t know how to do the question all you can do is leave it blank.”*
- *“Often it is easy to drop one mark (3/4 or 2/3) on short-answer questions with a minor mistake.”*

Opinion v performance

- Lower performing students tended to prefer MCQ over SA.
- *“Help work through process of getting right answer, a chance of getting it right if you’re clueless.” (rank 127th/192)*
- *“ If you are unsure of the answer you have a 1 in 4 chance even if you guess.” (166th)*
- Better performing students could see both advantages of SA and some limitations to MCQ
- *“It allows guessing most of the time rather than attempting to have a go. Also some students can guess and get it right. It doesn’t show their strengths or weaknesses.”(18th)*
- *“Helps students show their working out step by step for future exams, and rewards points for you step, rather than lose all of the marks. Also once you finished the test, you can look at what went wrong in your steps thus correcting the mistakes.” (15th)*

Conclusions

- Students preferred MCQ to SA ($p < 0.05\%$).
- Prompting the answer (MCQ) seemed to be something students liked.
- Showing what they know and partial credit were ideas that students liked about SA.
- Results generally concurred with literature.



Thank you