



What Students Think and How They Really Perform in Chemistry

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Abstract

This research was part of a larger study into student performance in senior chemistry with regard to question type and content. This paper examines student perceptions about question type and context and compares these perceptions to actual performance. How students perceive different types of questions and how it influences their self-belief and motivation were the focus of this study. Student responses to different styles or types of questions have been well researched over time. In this study Year 11 chemistry students were quizzed about their preferences to Multiple-Choice questions and Open Response question types and how the presence of each type was likely to influence their test performance. Student's perceptions were then correlated to their actual performance on sample chemistry tests. Students generally preferred MCQ questions and believed they were likely to perform better on these questions regardless of the topic. Test results did not always support this confidence.

1. Introduction

This study initially developed from the researcher's observations, along with those of a number of teaching colleagues, that there were apparent differences between the observed student performances in the State University Entrance (VCE) examination in Chemistry. Students were asked in interviews about their preferences in chemistry tests with regard to question content and type. Students were tested to measure actual performance and the two sets of data compared.

The research questions addressed in this study were:

1. 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.
2. Does student performance correlate with student perceptions about chemistry testing?

2. Gender differences in performance

Whilst there have been numerous studies examining various aspects of the gender participation and performance by males and females in mathematics and the sciences, these reports have focused on either science or mathematics in general terms. More pertinent to this research was a study that found females formed the larger proportion of all students studying all the sciences except physics, and, in terms of study score rankings, the females' outperformed males in all subjects except Chemistry [10]. Motivation is a key factor in determining success in education. The factors that affect motivation, both positively and negatively, are therefore important [6]. Success is important to motivation. A study by Ryan and Patrick [17] found that motivation and engagement by students was strongly determined by the motivation and engagement that had been developed in prior years.

3. Methodology

The open-ended structured interview is the most suitable for this particular research project. The targeted response areas are clearly defined thus suiting a formalized sequence of questions. The reliability of the interview is increased by greater control of the interview through a less open-ended response format (thus increasing the consistency of the responses) [1, 9, and 16]. All willing student participants (59) were interviewed using an open ended standardized interview [14]. Interviewees were each asked the same series of questions which were recorded by the interviewer. A detailed description of the interview questions can be found in the paper by Hudson and Treagust [13]. The data was gathered at four local secondary colleges in a largely affluent middle class suburb.

The researcher constructed short tests that asked essentially the same question but in both multiple-choice and short-answer form. Whilst some researchers [18] have made some assessments and conclusions about the advantages and disadvantages of each type of question, there have been few studies directed at examining the effectiveness of each type of question in how well they assess student understanding in chemistry [8].



4. Results

4.1. Results from interviews

Conducting the interviews provided a first person opportunity to determine whether or not the students' preferences on question types matched the actual performance on the tests. The majority of students indicated a preference for multiple-choice for responding to recall type content and short-answer for responding to application questions.

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

In response to the question: "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? That is which type of question do you like best? Chi-squared analysis of this data showed a value of about 4 with a significance of $p < 0.05$. The obvious differences between the data for males and females support results found through the observations of other researchers [3], though not strongly (See Table 2).

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

These results (Table 2) confirm the results demonstrated in Table 1. A strong preference was demonstrated for multiple-choice questions with males being the stronger supporters of the multiple-choice format

4.2. Sample test results

The performance summary of the sample tests is shown in Table 3. Detailed results of the sample testing can be found in the paper by Hudson and Treagust [13].

Table 3: Gender differences on the trial chemistry tests (means)

Groups	Count	Sum	Mean	s.d.
Male %	92	7364.2	78.3	15.8
Female %	90	6174.4	68.6	17.3

This table clearly demonstrates that the male students scored more highly than their female counterparts and this difference was significant ($F(1,181) = 15.9; p < 0.01$). Of interest was whether the attitudes of students to the various types of questions was reflected in the subsequent performance.



4.3. Student responses by interview question

Students were asked if the type of question in terms of content influenced their choice of question style. The majority of students, around 90%, interviewed preferred content or recall questions to be multiple-choice. The most common reason given seemed to be based on the idea that multiple-choice gave the students an opportunity to be prompted by the options. A number of students indicated the possibility of eliminating incorrect options as an advantage with this type of question.

Regarding application or calculation type questions the student view was quite clear. The students were generally of the view that short-answer responses gave them the best opportunity to perform well. There were, however, a number of students who preferred multiple-choice for both types of question. The percentage of students who opted for the short-answer application questions was about 70%. Typically the students indicated that the short-answer approach allowed them the opportunity to gain marks for correct working even if they could not provide the final correct answer.

A view held by the small number of students who preferred multiple-choice for application questions focused on the advantage of having the possible answer presented in the options and that having worked out an answer that was not an option meant that the students knew they had made an error and could then have a second chance at trying to calculate an answer that was presented in the options.

The responses from regarding the advantages and disadvantages as expressed by the students are summarized in Tables 4 and 5. As could be expected from different students, opposing viewpoints were often expressed. For example, some students thought that the larger number of marks attributed to a short-answer question was an advantage whilst others thought it was a disadvantage.

Table 4: Advantages and Disadvantages of Multiple-choice questions

Advantages	Disadvantages
Possible to eliminate or narrow down response.	Questions seemed designed to trick students
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
Can have an educated guess	Can't show your working out

Table 5: 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

Some of the comments from students that illustrated the results in Tables 4 and 5 were:

4.4. Multiple-choice advantages and disadvantages.

Female student B4: School-A: *"Sometimes because the answer is on the page you just need to select it"*
 Female student B4: School-A: *"You don't get any marks if you do the working out method partially correct but get the wrong answer."*

4.5. Short-answer advantages and disadvantages.

Male Student A3: School-D: *"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.”

Male student A17: School-D: *“Yes, if you don't know how to do the question all you can do is leave it blank”*

A particularly interesting observation is that the students who offered guessing as an advantage to multiple-choice questions were amongst the lower scoring students on the trial tests.

Male student C22: School-D: *“Help work through process of getting right answer, a chance of getting it right if you're clueless”*. This student scored an average of 65.3% and was ranked 127th amongst all the students.

Female student A23: School-B: *“If you are unsure of the answer you have a 1 in 4 chance even if you guess and you have something to work to”*. This student scored an average of 48.3% and was ranked 166th amongst all the students.

This contrasted to the better scoring students.

Male student A3: School-D For multiple-choice disadvantages; *“It allows guessing most of the time rather than attempting having a go. Also some students can guess and get it right. It doesn't show their strengths or weaknesses. Also skipping steps rather than showing how you got there. Also if you were taught the wrong method of working, it doesn't let the teacher know or you. Thus not allowing you to correct an error.”* This student scored an average of 93.1% and was ranked 18th amongst all the students.

5. Conclusions

A sample (59) of the 192 students was interviewed. With respect to the preferred type of question the students indicated a significant ($p < 0.05$) preference for multiple-choice (59%) over short-answer. The results support those previously found in the literature [19]. Generally the strongest features reported by students in favour of multiple-choice were that the options offered prompted them towards the correct answers, allowed the possibility of cross checking results from calculations and finally offered the possibility of at least being able to make an informed guess rather than leaving a blank space. Students who favoured short-answer questions most often offered the response that it gave them the opportunity to gain partial credit for incomplete responses and also the opportunity to “show what they knew”. Overall the results of the interviews were indicative rather than conclusive but generally supported the findings of previous research.

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