

WRITING: IS IT IMPORTANT IN SCIENCE CLASSROOMS?

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In recent times there has been much debate about the literacy levels of students in our schools. Federal and State Governments have provided extensive resources to improve the literacy standards of our tertiary, primary and secondary students. As part of this emphasis on literacy the role that writing plays in student learning has been acknowledged. Recent research has shown that the majority of student writing in secondary science classrooms is teacher directed and used for student assessment. With much of what students write being directed towards assessment it seems timely to research student and teacher views of the role that writing plays in science classrooms. This report uses a questionnaire, teacher interviews and an open-ended survey. Data analysis indicated that teachers from all key learning areas agreed that students' writing skills were lacking and that the students appeared to be unable to successfully incorporate the use of subject specific terms to enhance their writing. It was also found that students disliked writing. However, they wanted to improve their writing skills as they perceived that good writing skills were necessary to help them achieve their best and demonstrate their learning at school.

Key Words: science education, writing, literacy, qualitative research, teacher research, action research

INTRODUCTION

Literacy skills in Australian schools have been the subject of much recent controversy with science classrooms, both primary and secondary, attracting their fair share of attention. The media have made highly emotive claims that many children are being disadvantaged by the perceived inability of some schools and teachers to impart basic literacy skills and the affect this is having on their future vocational prospects such as in the article. "Only one in five get it write at work" (Harvey, 1999). Conversely, politicians have recently congratulated themselves and the education system for the high level of literacy in classrooms based on data collected from Basic Skills Testing in Years 3 and 5 (London, 2001; Baird, 1999). However, what really happens in the classroom can sometimes become obscured behind the media hype.

In secondary schools, there is a reliance on student-produced writing for evaluation of academic progress. Over the last twenty five years research has shown that when students moved from primary to secondary school that there was a shift from student controlled writing towards teacher driven writing tasks (Green, 1998; Britton, Burgess, Martin, McLeod & Rosen, 1979). It was found that 87% of student writing in science was directed towards the teacher and solely for the purpose of assessment. The form that these assessments take may vary, but the process has remained the same; the students write and the teacher grades the work. As such, success becomes a matter of learning the subject matter and the necessary skills, and then being able to respond in writing to questions about that material. Written responses to questions are still the major tools for communicating a student's understanding of particular concepts and ultimately the measure of student progress; those that are unable to write well are immediately disadvantaged.

As a science teacher, the author has witnessed student difficulties that have led to negative student attitudes to science, and in particular writing in science. So the focus of this study was student writing. The author had recognised that students demonstrated their understanding of science well orally but appeared to have difficulty in expressing this knowledge in writing. As part of this study into student writing teacher interviews were conducted to establish whether fellow teachers shared similar concerns about student writing in their subject areas. The data collected from teachers over a range of subjects would be used to identify issues relating to student written literacy and to inform the research into student writing in science.

The theoretical framework for this research was derived from Prain and Hand's (1996 a, 1996 b) research that outlines both a pedagogical and theoretical model for improving writing practices in secondary science classrooms. The five parts of this model focus on writing types, purposes, audiences (or readership), topic structure and method of text production. Subsequently Yore, Hand and Prain (1999) identified that one of the barriers to scientific writing was "the lack of a clear image of a successful writer" (p16). These authors' work informed this study by identifying characteristics of such a student in so much that good writers spend more time in the prewriting stage than poor writers and produce longer text (Ferrari, Bouffard & Rainville, 1998).

The literature reveals that there has been significant research into student writing where the focus has been on creative and essay writing (Graham, 1990; Graham & Harris, 1997) and in recent times there has been an increasing amount of research and debate over the use of writing-to-learn strategies in science classrooms (Holliday, Yore & Alvermann, 1994; Rivard, 1994; Prain & Hand, 1996 a). The issue of writing in science has been addressed by comparing the use of traditional writing tasks (summarising and short paragraph

writing and short answer writing) and non-traditional tasks (essay and story writing) finding that the later induced greater learning of scientific concepts (Keys, 1999). Bereiter and Scardamalia (1987) argue for the use of 'writing for knowledge transformation' rather than 'knowledge telling' where the learner engages their prior knowledge and constructs links with their current observations through the use of a writing task. Their cognitive model clearly reflects the views of constructivist approaches and allows for the learning in science to focus to some extent on improving student scientific literacy and develop conceptual knowledge of science (Keys, 1999). Others have used non-traditional writing activities that have focused on developing different writing types (story telling, advertisements, brochures) for a variety of audiences (Hand, Prain & Scholes, 1996).

Prior research in secondary schools (Gregson, 1996) indicated that students encounter difficulty in writing about their understanding of scientific concepts and that there has been a need to develop specialist literacy programs to provide help for students whose academic progress has been impeded by their inability to express themselves in writing. To this end this study investigated student writing and students' and their teachers' views of writing at this school in an attempt to identify specific writing difficulties that the students are experiencing. The research question was is writing perceived as a problem for students, particularly in science, at this school?

CONTEXT

This study focuses on students in a coeducational, non-government school in metropolitan Sydney, New South Wales. This school has a population of 920 pupils, K-12. The pupils come from a variety of backgrounds and are not generally economically disadvantaged. Science at this school is compulsory in year's 7-10 and optional in years 11 and 12. The survey described in the method was

administered to the students at the end of one school year with the interviews and open-ended survey conducted the following year.

The author was the classroom teacher who conducted the teacher research at the school site while the co-author was an academic who provided supervision of her doctorate and became a co-operative partner during analysis of data and subsequent preparation of action research cycles. This study represents the first of five phases of the research.

METHOD

To address the questions generated in the introduction data was collected in three ways. Firstly, all secondary students (n=480) at the research school were asked to respond to a questionnaire about their school, their subjects they studied and about writing. A scale was used where the students responded to statements such as "I find writing what I mean to say difficult" by choosing from the following list of alternatives: almost always, usually, sometimes, rarely and never. The students' responses to every statement were tallied and recorded systematically with percentage frequency for responses calculated. Secondly, semi-structured interviews explored views on writing of 16 teachers from six different key learning areas (from the research school) and 15 other science teachers; four from NSW government schools, eight from non-government schools and three from the TAFE sector, who volunteered to participate in the research.

The teacher interviews were audio-taped, subsequently transcribed and returned to the teachers to be member-checked. The data were then read four times to categorise the teacher responses into themes. The first reading of comments sought to identify *similarities* in responses; that is, while the wordings may have been different, many comments reflected similar meanings. The second analysis focused on findings which reflected *differences*

in responses. The third criterion for grouping of data was one of *relevance* to student problems and writing. In the fourth analysis the teachers' statements were grouped into categories such as student behaviour, student expectations, writing requirements in their subject area, and perceived difficulties that the students had with writing. This multi-layered approach reflects that recommended by Marton (1994) and Burns (1994).

The third source of data was an open-ended survey of a Year 8 lower performing science class (17 students) that related to their feelings about science; what they liked and disliked; what they thought they were good at and what they thought they needed help with to improve in science.

FINDINGS

Whole Secondary School Survey

Each school student in Years 7-11 (Year 12 had examinations at this time) was asked to respond to a set of questions about the school, their learning potential at the school and their ideas on writing. For the purposes of this article, only the sections of the questionnaire relating writing will be reported. In this section of the questionnaire students were asked to consider 18 statements about writing, their writing abilities and the affect that their writing skills have on the progress they made in their subjects. For example most students were satisfied that they could write clearly and concisely responding with either 'Sometimes', 'Usually' or 'Almost Always' but there were students (Year 8; 9%, Year 9; 10%) who thought that they would rarely or never express themselves clearly.

The students' responses to the statement about their standard of writing and how their writing ability affected their marks revealed no strong views as 'Sometimes' was the most frequently chosen alternative by the Year 8, 9 and 11 students. In Year 7, 40% of the students indicated that writing 'usually' helped them to learn; Year

8 and Year 10 students responded similarly. However, in Year 8, 38% identified that they 'never' or 'rarely' liked writing compared with Year 7 (17%), Year 9 (28%), Year 10 (28%) and Year 11 (34%).

Most of the responses to the statements throughout the survey showed a peak at 'usually' or 'sometimes' but there were two exceptions. When asked to respond to the statements "I would like to do better at school" and "I would like to be a better writer" over 50% of students in each year group chose 'Almost Always'. While it is perhaps understandable that the majority of students would like to do better at, it seemed extraordinary that so many students identified that their writing ability needed improving and expressed a desire to do so.

TEACHER INTERVIEWS

To explore the need for further research into student writing the teachers interviewed (n=31) were asked what they perceived to be the problems that students were experiencing in their subject areas. Without prompting, writing was identified as a problem for students in all of the teacher interviews. The interviewees indicated that their students were unaware of the expectation of their teachers when it came to writing. The students either wrote too little, therefore not completely answering the questions, or too much with a tendency to 'waffle'. Many were said to have difficulty recognising how to write for different audiences and in different genres. Jane elaborated,

Jane (PDHPE): It [Personal Development/Health/Physical Education (PDHPE)] is a more academic subject than students think and there is a lot of writing and essays and not so much practical as they think. I think they still come into the course expecting to play around the oval. They don't expect the rigour of the course.

Aileen (Business studies): The hardest thing is to get them to write a report. They want to write twenty pages of essay.

The teachers were unanimous in their acknowledgement of how important student writing is, including that the students need to be aware of the purpose of their writing. In the interviews teachers also observed that the lack of use of subject specific terms was a common problem. Every teacher interviewed referred to the use of technical language and the difficulties that their students appeared to have in its use. According to these teachers, students too often failed to recognize the significance of the terms their teachers introduced in the classroom and this led to the students not incorporating the terms in their answers in essays, reports and examination questions.

Aimee (Business Studies)... they think that these are just words that I am using and that they are not required to use them...they talked [wrote in essays in examinations] all the way around it [the term] without saying the word, because if you are using business language you don't have to use as many words to explain it [the concept].

Jane (PDHPE): To get good marks in this subject you have to use the correct terminology.

Audrey (History): Understanding terminology is being able to think in context of the society ... you have to be able to relate to what the word means to be able to understand the content of the lesson.

Laura (Visual Arts) ... terminology is very important, they really should be using visual arts language when they write.

During their interviews the science teachers demonstrated that they were aware some of the difficulties some of their students had and acknowledged the role that writing played in the study of science. The teachers' concerns were varied and included the student's apparent lack of experience with writing in different text types, their use of specific scientific language and their lack of ability to be good communicators.

Phillip drew on his experiences of working with primary-aged children and suggested that:

In primary school, students are encouraged to write about their experiences in their own language and in a more narrative style. Upon entering high school, some students find it difficult to translate their knowledge of science into a more structured style of report writing, where they are expected to use the technical language that is required at the secondary level.

As a very experienced science teacher, he also claimed that:

As science teachers, we are fairly loathe to do what seems to be the job of the English staff ... after all, we didn't get a science degree to become an English teacher. So I think that a lot of science teachers want to get into the science concepts, get them done and that is it. I think the teaching of genre and scaffolds are beyond the interest level of science teachers.

He went on to explain that, in primary schools, students are familiar with many styles of writing but when they come to secondary school and try to use them in class, their science teachers find them unacceptable. He believed that science teachers prefer note taking and report writing.

I think the teaching of genre and scaffolds are beyond the interest level of science teachers... in primary schools, students are familiarised with many models of writing and that, when they bring these to science class, their secondary science teachers find them unacceptable.

Students bring skills and experiences with them as they pass from primary to secondary school. Many secondary teachers, however, have unrealistic expectations of their students' literacy skills. During informal discussions with teachers throughout the author's career the author has gained the impression that secondary teachers have the view that all students come into secondary school

with sufficient literacy skills to allow them to immediately adjust to the different styles and genre of writing required across all subjects. Furthermore from the observations of their students' writing and ability to express themselves teachers make judgments about the student's academic ability. When asked the question "what makes a good writer?" the teachers interviewed responded in a variety of ways.

Keith suggested that a creative writer was a better scientific writer. He said:

Creative writers are better writers because they have learned to think laterally. They can take the stuff and really work with it ... others who are not necessarily thinking creatively – to them, it is just another task to do.

Rose (a science teacher with 25 years of teaching experience) related students' ability to be good writers to their ability to be clear thinkers. She said:

They [the students] need to be able to put information in sequential order, so that it is logical and will convince another person of their understanding of the information or concept... if students are good communicators, they are more likely to put down what they know. If they are not good communicators, they may not be able to put it down on paper, but that doesn't mean that they don't know it, just that they can't put it down on paper.

Rose expanded her argument to suggest that students described as 'more able' (later clarified as those with 'higher order thinking skills' and 'higher intelligence') tended to be able to write more specifically and to have the capacity to produce more scientifically-correct responses to examination questions. Thus equating writing ability with academic success and academic ability and suggesting that the information teachers use to make assumptions about student ability are based on the students' written work.

In terms of the science examinations that are part of the School Certificate and Higher School Certificate, Phillip's view was 'that students who used scientific terms were "streets ahead" of other students'. He also suggested 'that this particular skill was what examiners were looking for'. However this appeared to be contradictory to Phillips' observations in the classroom where he suggested that there were different expectations from students when they demonstrated their knowledge orally and in the written form. It was apparent to him that there was an acceptance of student explanations where they use 'common language during classroom activities, discussions or class tests and then are expected to use more scientific language across the grade examinations'. Phillip thought that many teachers accepted student comments during class discussions that incorporated too much colloquial language about concepts, rather than expecting the students to use more specialised language. He also commented on the change in teacher expectations as students move from junior to senior science classes. He said 'long winded' answers accepted in junior school are not acceptable in HSC examinations. Students are given limited space in these external exams to express themselves and they often have difficulty coming to the point in a few lines'.

Keith observed that students appear to be unaware of the depth and breadth of the responses required in assessment tasks; that 'lower level kids tend to give only a few bits of knowledge that everyone would give. A higher level student will give the same three bits of knowledge that everyone else gives and then give a bit extra'.

Edith noted that students have difficulty in linking their responses to the stimulus material supplied. She said 'if there is a graph or a picture and the question relates to the picture, "lower ability kids" do not relate their answers to that material. Most students need to give more information, more detail. A lot of them only write two or three sentences when they need to write two or

more paragraphs'.

The author's experience is that many students are unaware of what teachers are looking for when they assess student work. Many students, and not only those labeled as 'lower achieving', take a minimalist view and provide simple and brief answers in the belief that they have answered all parts of the task. In some cases, the students attempt to complete the work quickly so that they may move onto something more interesting. In their rush their response often fail to address all parts of the task. Other students will try and write down everything they know that is related (and, in some cases, unrelated) to the topic, in the hope that they may gain maximum marks through sheer volume. Teachers observed that the extra material offered rarely added any quality to the students answer and therefore did not lead to higher marks being awarded. These examples support the theory that there is a gap between students' perceptions of what they write, what they know and their teacher's perception of what they read when marking student answers.

Some teachers interviewed commented that the number of lines offered on which to write their answers does not seem to give the students an idea of the extent of the response required. Students also seemed to be confused about what to write as on return of their examination papers students made comments such as 'I did not get the mark I thought I deserved because there was not enough space in which to answer. One student even commented "but that is what I meant to write" when comparing their answer to the 'correct' answer offered by the teacher. Here the student claimed that they understood the scientific concept and expressed it in their answer with the intention of conveying the very meaning expressed by the teacher (This had been noted by the authors). Yet their response does not convey this same meaning to the teacher either due to the students' written expression or the teacher's interpretation of what the student had written.

SCIENCE RESEARCH CLASS STUDENT SURVEY

In this study 17 students in a lower performing Year 8 class were asked to write responses to open-ended questions that related to their feelings about science, what they liked and disliked, what they thought they were good at and where they thought they needed help. The purpose of this activity was to record the students' perceptions of science as an area of study; identify their attitudes to science; ascertain which areas of the subject were interesting, difficult, enjoyable or disagreeable to each student; provide the opportunity for the students to identify areas where they had existing problems and provide an initial opportunity to assess their writing skills and their ability to express themselves.

The survey responses established that the students in this particular group enjoyed practical activities (which is consistent with the findings of Gregson, 1996). They also thought that they were adept at performing experiments. When asked to identify areas of science that they did not enjoy, writing, of one form or another, was specifically mentioned by 11 of the 17 students. The types of writing that the students made reference to included writing reports of experiments, homework, answering questions and summarising from their textbook. Tina suggested that she found essay writing difficult which, was an unusual response as this type of writing activity is rare in science classes at this school.

Students' comments included:

Louis:	there is a lot of writing involved in science
Katherine:	I hate having to answer questions
Nigel:	boring book work
John:	the writting (sic)
Jonathon:	do more physical stuff and less writing

When asked to identify areas where they needed help, some made suggestions that they needed help in 'basically everything'. Others specifically mentioned writing, with regard to writing up their experiments and accurately recording the results.

James: Writing the experiments (sic) down on paper

Teena: Understanding some of the questions in exam papers

Simon: Recording results

The survey responses clearly established two points; that the students in this particular group enjoyed practical activities and that writing was an activity they did not enjoy. They do not like 'lots of writing', 'boring bookwork', 'answering questions', 'writing down experiments' and 'questions in exam papers'. While the students liked some aspects of science one key aspect they did not like was writing.

DISCUSSION

This study emanated from an awareness that some students had a negative attitude to science and that there were students in the lower streamed classes who were more capable than their marks reflected. Through a lack of success in tests and examinations they saw themselves as 'not good' at science and this promoted the development of their negative attitude to science. From classroom discussions with these students it became apparent that they did understand many of the concepts taught but were unable to express their ideas clearly when writing.

The questionnaire, teacher interviews, open-ended survey and personal experiences highlight issues of significance to the science education. Both teachers and students were aware of the need to improve writing skills and the role they play in achievement at science.

To be a good writer in science, students need to be good communicators. This means being able to put information in a sequential or logical order, in order to convince a reader (often an assessor) of their understanding of relevant concepts. If they are good communicators, they are more likely to accurately record what they know. The science teachers interviewed suggested that often students produce written work that does not represent the extent of their understanding of scientific concepts, denying the students the rewards they deserve in classroom tests and examinations. Furthermore, writing answers that are too brief or answering with every detail known about the topic can result in ineffective communication.

It seems that there is invariably some expectation about the extent and depth of treatment in a response to a question that is clear to the teacher but often unclear to many students. Like the three bears' bowls of porridge only one of many answers is "just right" and teachers taste in answers may seem as fickle to students as the taste and perceptions of Goldilocks.

The observation that students often appear to understand ideas in class but fail to demonstrate in response to formal assessment begs the following questions. Are those who are unable to write well inappropriately labeled as 'low ability' and of 'low intelligence'? And if a student is not a good writer, can he/she be taught to improve their writing skills and, as a result, improve his/her ability to communicate their understandings? Further research needs to be done to explore the view that is broadly accepted by teachers, that what students write is an indicator of the extent of what they know.

Many students have a negative attitude to writing. The students in the research class did not like writing. They were more than happy when involved in practical work but did not like recording their ideas about the experiment in their books. Clearly then writing

is an important feature of schooling that influences student achievement. Writing skills have enormous implications for all students' success. Pivotal examinations for students in Year 10 and 12 use written responses as the major determinant of student achievement, understanding and knowledge acquisition. Therefore, those who have a limited ability to express themselves in writing are immediately disadvantaged.

If teachers are assessing students' work based on the level of use of specific scientific terms then the students need to be aware of this and pedagogy implemented to ensure that students become proficient at using them. In doing so the students become aware of the needs of their audience (usually their teacher) which will help them to express their ideas to that audience. Alternatively, science teachers may need to review their expectations and focus on understanding rather than the language used to convey the understanding. The teacher, as the reader, also needs to be more aware of what students are trying to say in their writing when they try to express their understanding of complex ideas. The tendency of students to use their own words creates conflict with some teachers' expectations of students using specific terminology. There is a need to work with teachers and policy makers to reappraise the emphasis placed on writing and the types of assessment tools used as key indicators of student knowledge.

CONCLUSION AND IMPLICATIONS

The perception that teachers may equate students' intellectual ability with their ability to write is critical to the judgments that teachers make about their students. Written responses remain the means of assessment in all external science examinations and as such are testing the students' ability to respond to a set of questions with the assumption that what the student writes represents their understanding of the subject matter.

The assertion is that poor writing skills may engender a lack of success in science, which markedly affects the students' attitude to the classroom activities, enthusiasm for learning content and may, in turn, influence their selection of science for further study at senior level. Some of the science teachers in this study had indifferent or negative attitudes to literacy being an integral part of teaching. There were those that believed that the teaching of literacy should be left to those who are trained as English teacher. Here lies one of the difficulties, some experienced science teachers may lack the training or will to use a range of literacy strategies in their teaching of science. The lack of teacher knowledge and understanding of literacy issues in science is a challenge that needs to be overcome so that teachers can develop activities that focus on written literacy.

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