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A Comparison of Teachers' and Students' Rankings of Practical Work Objectives in 'A' Level Chemistry

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Abstract

The purpose of this investigation was to compare teachers' and students' rankings (in order of importance) of A Level Chemistry practical work objectives and also determine whether the perceptions were related to some chosen educational variables. Teachers' (n=39) and students' (n=107) views on the importance of chemistry practical work objectives were obtained through questionnaires. The results showed that teachers and students generally disagreed on the order of importance of A Level Chemistry practical work objectives. Correlational analysis of the responses revealed that teacher perception of the importance of practical work objectives is not related to the variables, teacher gender, qualification, teaching load, class size, choice of teaching method, availability of apparatus and chemicals and laboratory assistance. Student perceptions are also not related to gender factors and A Level subject combination. It is recommended that teachers take cognisance of student views when planning for chemistry instruction.

Introduction

Practical work is central to science instruction. Science instruction without laboratory work is unthinkable. Teacher and student perceptions of the purpose of laboratory/ practical work have a direct bearing on the manner in which the teaching and learning

of a science such as Chemistry will take place. Devenport, Lazonby and Waddington (1979) are of the view that views of students and teachers maybe taken as reliable indicators of classroom practices. Teacher perceptions of practical work objectives have an influence on how a teacher chooses the method/strategy/technique of practical work instruction and how he/she organises laboratory work. Equally, student perceptions of the purpose of practical work have a direct bearing on student behaviour and motivation during laboratory work. Information about what teachers and students think are the most important objectives of laboratory work is of educational value because of its use it in instructional planning. The information may also be useful in identifying appropriate content and skills, and in student evaluation in Chemistry education at both the school and teacher-education levels.

A similar study, Lynch and Ndyetabura (1983) surveyed Tasmanian matriculation level science students and science teachers in high schools and matriculation colleges. The study showed that teachers and students had significantly different perceptions of the objectives of practical work. An inquiry into Scottish Alternative Syllabus in 'O' Level Chemistry by Gunning and Johnstone (1976) revealed that teachers' and students' rankings of the importance of practical work objectives were different. Perceptions of practical work objectives were found not to be related to students' gender. The differences between previous studies and this one are that, first, as far as can be ascertained, no studies have been done to compare 'A' Level students' and teachers' perceptions of the purpose of practical work in 'A' Level Chemistry. Secondly, prior studies have done little to investigate possible associations between teachers' and students' perceptions and such educational variables as teacher gender, qualification, teaching load, class size, preference of teaching method, availability of laboratory resources, availability of laboratory assistance, student gender and 'A' Level subject combination.

The major purpose of this study therefore was to compare teachers' and students' rankings in order of importance, of 'A' Level Chemistry the objectives: and also find out whether the perceptions were related to the educational variables stated in the above paragraph. For all tests the significance level was set at 0.01. In line with this purpose the following research questions were posed:

1 Is there concordance/discordance between teachers' and students' rankings of the importance of 'A' Level Chemistry practical work objectives?

2 Is there a relationship between teachers' or students' perceptions of the four broad practical work objectives and the variables: gender, qualification, class size, choice of instructional strategy, teaching load, availability of resources, availability of laboratory assistance and student 'A' Level subject combination?

Literature Review

Practical work or laboratory work is taken to mean those activities carried out by the teacher, the teacher and the students or the students on their own in order to accomplish experiments or demonstrate scientific phenomenon. For science, practical work can be carried out inside or outside the laboratory or classroom. It is an activity during which there is physical manipulation of apparatus, objects and materials. As a result of the manipulation, the object or material must be able to reveal some observable phenomenon. Basically, observation and experiment are the key in science practical work. Activities in which observation and experimentation are not involved, it can be argued, do not constitute practical work for science instruction and learning. In a review of research on laboratory work, Gallagher (1987) points out that the questions underlying many studies imply uncertainties about the instructional role

of laboratory work at the secondary school level. For example, Byrne (1985) is of the opinion that much practical work only serves to develop manipulative skills. What exactly then is the purpose of laboratory work? What objectives do teachers and students perceive to be important for practical work?

Writing on practical work objectives, Swain (1974) summarises attempts that have been made at producing statements of practical work objectives since 1937. A practical work aim/objective is an intended outcome after a suitable practical course or experiement has been done (Swain, 1974). The intended outcomes include psychomotor, cognitive and affective domains of educational objectives. Although Swain (1974) mentions works by a number of writers, it is the work of Matthews (1969) (in Swain, 1974) which is of relevant interest as it deals with objectives for Nuffield 'A' Level Chemistry. Matthews listed the objectives for 'A' Level Chemistry practical work as; skill in observation, interpretation of observation, manipulative skills and attitude to practical work (Swain, 1974).

A consideration of the history of the development of practical work objectives in the 1940's and 50's reveals that in many parts of the world, the principal aim of teaching chemistry was direct recall of factual knowledge (Ashman, 1985). During the 1960's and 70's there was shift in emphasis from simple acquisition of knowledge to a desire to develop process skills in students (Hodson, 1996; Swain, 1972; 1988). Practical work in science was seen as important in developing the skills and techniques of scientific inquiry (practical skills). Practical skills are mainly manipulative skills; appropriate abilities (cognitive and psychomotor) which students should posses as a result of doing experiments or in order for them to complete experiments (Farmer & Frazer, 1985). The practical skill is mastered through repetition of practical tasks.

As ideas on what should be the principal aim of practical work changed gradually over the years, so did the methods employed in establishing criteria for ranking importance of practical work objectives. Before 1970, the views of scientists, chemists and education authorities (university lecturers) on what constitutes practical work objectives were taken almost on faith as authentic. After this period, researchers started looking into the views of teachers and students on practical work objectives. Gunning and Johnstone (1976), Tobin (1986), Johnstone and Letton (1990), Denny (1986) and Devenport, Lazonby and Waddington (1979) examined the views of students and teachers on practical work objectives in Chemistry. Of these studies, only the one by Denny (1986) suggests a concordance between teachers' and students' perceptions of the objectives of practical work. The other studies indicate that teachers and students do not view practical work objectives in the same manner. Generally, the studies reveal that students do not find practical work to be as interesting as the teachers think. The studies showed that perception of the purpose of practical work is not related to student gender (Lynch & Ndyetabura, 1983) and the amount of practical work given to students (Gunning & Johnstone, 1976). It would be interesting to find out how other educational variables relate to teacher and student perceptions of laboratory work objectives. Analysis of the afore-mentioned studies show that the major objectives of Chemistry practical work generally reduce to the ten as listed by Gunning and Johnstone (1976). According to Gunnstone and Johnstone (1976) the main objectives of practical work in chemistry are that students should be able to:

1 Draw conclusions from experimental results,

2 Develop an interest and enjoyment in chemistry,

3 Appreciate that chemical theory describes real observable phenomenon,

4 Work safely and tidily in a laboratory,

5 Carry out written and oral instructions,

6 Record observation and results,

7 Acquire skills in handling apparatus and chemicals,

8 Develop a sense of curiosity,

9 Design an experiment to investigate a problem, and;

10 Appreciate that there are limitations in accuracy involved in practical work.

These ten aims can be grouped under three major categories of practical work objectives given below (1, 2 and 3). To these three, 4 can be added as another major objective.

1 Development of practical skills (mainly manipulative),

2 Promoting motivation (interest and attitudes towards chemistry),

3 Enhancing students' knowledge of chemistry, and;

4. Preparing students for examination.

These lists of ten and four broad objectives were used in this study to elicit teachers' and students' perceptions of practical work objectives. The categorisation into four broad objectives gets support from practical work objectives listings by Denny (1986) and Tobin (1986). Within this realm of broad objectives, the laboratory focuses on the achievement of conceptual and cognitive goals; psychomotor goals; scientific process goals and affective goals. In some educational contexts (Zimbabwean education system), preparation of students for practical examinations is very serious business.

Methodology

The Research Design

This descriptive study used a questionnaire survey. Questionnaire surveys have been used successfully by Lynch and Ndyetabura (1983), and Gunning and Johnstone (1976) to elicit and compare teachers and students views on science and chemistry practical work objectives respectively. Since this study sought to compare teachers' and students' perceptions on the same subject of practical work objectives, the use of questionnaires to collect data was seen as appropriate.

Sample

Thirty-nine (39) teachers completed and returned the questionnaires representing a 36% response rate. Twenty-seven (27) (69%) of the teachers were males and 12 (31%) female. The average teaching experience was between 5 and 10 years and the average 'A' Level Chemistry teaching experience was between 6 and 10 years. Teacher qualifications are summarised in Table 1.

Table 1
Teacher Qualifications

	Qualification			
	BEd.Chemistry	BSc. Ed/BSc+Grad. CE	BEd.Chemistry	MSc.Chemistry
Frequency	9	9	20	1
Percentage	23	23	51	3

Thirteen percent (13%) (5) of the teachers were teaching lower sixth chemistry. Thirty-three percent (33%) (13) were teaching upper-sixth chemistry and 54% (21) were teaching both upper and lower sixth chemistry, in addition to other teaching loads in the sciences and mathematics. Of the surveyed teachers, 67% (26) did chemistry as their major at university.

The students (n=107) used in this study were obtained from a sample of ten Zimbabwean high schools (n=110) offering 'A' Level Chemistry. The students' average age was 18. Altogether 13 female (12%) and 94 male (88%) students completed the questionnaire. All students involved were doing upper-sixth. No student was repeating 'A' Level. At 'O' Level all students had done either Physical Science, Physics and Chemistry or Biology and Chemistry in addition to Core Science (Integrated Science). For the students the most common 'A' Level subject combination was Chemistry, Biology and Maths.

Educational Variables Data

The average 'A' Level Chemistry class was 26. Twenty-three percent (23%) (9) of the teachers reported that they had classes of at least 31. For the surveyed teachers, the

most popular teaching method was the lecture. More than 90% of the teachers thought the 'A' Level practical examination is difficult for students. The average number of teaching periods per week for the teachers was between 24 and 30 forty-minute periods. Eighty percent (80%) (31) of the teachers report that at their school there is a laboratory reserved only for A Level chemistry. Ninety-five (95%) (37) of the teachers have a lab assistant or lab technician to assist them. Generally, teachers report a shortage of apparatus. Sixty-two percent (62%) (24) of the teachers report that they have failed to do some practical work because of shortage of apparatus or chemicals. All teachers reported that students shared apparatus in pairs during practical work.

Instruments

The instruments used in this study are adaptations of the ones used by Gunning and Johnstone (1979) and Lynch and Ndyetabura (1983). The validity of the objective items was established by Gunning and Johnstone (1976) in their study involving Scottish 'O' Level Grade Chemistry students. Asking respondents to respond to the importance of practical work objectives in the manner done in this study was successfully done by Lynch and Ndyetabura (1983) and Gunning and Johnstone (1976). Test re-test reliability coefficients (for the used versions) were 0.84 for the teacher questionnaire and 0.78 for the student questionnaire.

The teacher and student questionnaires asked for similar information. Part one of each questionnaire asked the respondents for demographical information. For teachers, information was sought on, gender, type of school, academic and professional qualifications, teaching experience, load, class size, favoured teaching method, availability of laboratory assistance and apparatus. Students were asked to

provide information on gender, 'A' Level subject combination, sciences done at 'O' Level and sharing of apparatus during practical work. These variables were necessary to answer Research Question 2.

Part two of the questionnaires was of the Likert type. In this section, the teachers and students were given a list of ten practical work objectives. For each objective, respondents were asked, to indicate whether they thought the practical work objective was, Important (I), Fairly Important (FI), or Not Important (NI) by ticking in the appropriate box. Information gathered from this section of the questionnaire was used in answering Research Questions 1 and 2.

Part three asked the respondents to rank four objectives of practical work on a scale of 1 to 4, with 4 being the least important. The rankings done by the teachers and the students were used to answer both questions of the research problem. Below is a list of the four broad objectives:

1 Acquisition of practical skills (mainly manipulative),

2 Enhancing students' motivation and attitudes in chemistry,

3 Enhancing students' knowledge in chemistry, and;

4 Preparing students for examinations.

Data Analysis

To find out whether or not teachers' and students' rankings of the importance of the ten practical work objectives showed concordance or discordance, the frequencies of teachers and students responding to each category on the Likert scale were obtained. 'Important' percentage responses for students and teachers were matched objective for objective. Teacher and student rankings of the ten practical work objectives were obtained by considering the 'Important' percentage response. The higher the percentage response for the objective the higher the ranking. Comparison of teachers' and students' rankings is also done graphically. Graphical comparisons of the views on importance and the rankings are done by means of a two way plot of the rankings against the objective number which also corresponds to students' ranking. Lynch and Ndyetabura (1983) used a similar technique in their comparison of teachers' and students' perceptions. Rankings of the four broad objectives were also done using frequencies as was done with the rankings of the ten objectives. For these objectives, finding out whether or not teachers' and students' rankings coincided was done using the chi-square statistic. Yate's correction for continuity formula was employed with significance set at 0.01 for a two-tailed test. Determination of association between variables (Research Question 2) was done using the Pearson correlation coefficient.

Procedure

The questionnaires were administered during the schools' second term. Teacher questionnaires were mailed to 110 'A' Level Chemistry teachers in Zimbabwe. Each Chemistry teacher was asked to complete the questionnaire and return it to the researcher in the stamped envelope provided. A total of 39 teachers (36%) returned the completed questionnaires. The researcher in person administered the student

questionnaire. 'A' Level Chemistry students (n = 107) were obtained from a sample ten high schools in Zimbabwe. Of these schools five were Mission Boarding Schools and five were Urban Day Schools. The total 'A' Level Chemistry student population in Zimbabwe at the time of the study was about 2000. At each school the students sat in one classroom and completed the questionnaires in the presence of the researcher. On the average students took between 30 and 40 minutes to complete the questionnaire.

Results

The evidence is presented under the research questions.

Research Question 1: Is there concordance/discordance between teachers' and students' rankings of the importance of 'A' Level Chemistry practical practical work objectives?

Table 1.1

Discordance between Teachers' and Students' Rankings of the Importance of Ten Practical Work Objectives.

Practical Work Objective	Response: Subjects saying objective is Important					
	Students (n=107)		Teachers (n=39)		Rankings	
	f	%	f	%	f	%
Be able to draw conclusions from experiments	97	92.5	37	94.9	1*	1*
Be able to record observations and results	94	87.9	35	89.7	2*	2*
Acquisition of practical skills	90	84.1	31	79.5	3	5
Be able to work safely and tidily in a laboratory	89	82.2	32	82.1	4	3
Develop an interest and enjoyment in Chemistry	83	77.6	27	69.2	5	7
Be able to carry out written and oral instruction	78	72.9	29	74.4	6	6
Appreciate that theory describes real observable phenomenon	68	63.6	32	82.0	7	3
Appreciate that there are limitations in accuracy in practical work	65	61.0	19	48.7	8	10
Be able to design an experiment to investigate a problem	64	59.8	23	59.0	9*	9*
To develop a sense of curiosity	46	43.4	24	61.5	10	8

*Student and teacher rankings coincide

Objectives

Table 1.2

Chi-Square Test of Concordance Between Teachers' and Students' Rankings of Importance of Four Major Objectives of Practical Work.
X^2 critical = 6. 63

Objective	X^2 Observed	Df	Signif.	Responses saying most important				Rankings	
				Teachers		Students		Teachers	Students
				f	%	f	%		
Enhancing student knowledge in Chemistry	30.40	1	0.01	33	84.2	33	30.5	1	4
Acquisition of practical skills	9.41	1	0.01	29	73.2	46	42.9	2	3
Preparing for examination	9.32	1	0.01	10	26.3	57	53.3	3	2
Enhancing student motivation and attitudes in Chemistry	33.80	1	0.01	8	21.0	80	73.3	4	1

In all cases X^2 observed > X^2 critical. This means as far as the four objectives are concerned teachers' and students' rankings show discordance. Rankings are opposite each other.

Research Question 2: Is there a relationship between teachers' or students' perception of the four broad practical work objectives and the variables: gender, qualification, class size, choice of instructional strategy, teaching load, availability of

resources, laboratory assistance and student 'A' Level combination? The Pearson correlation coefficient was used with significance set at 0.01.

Table 1.3

Results of Cross-tabulations Showing Lack of Relationship between Teachers' and Students' Perceptions of Practical Work Objectives and Chosen Educational Variables

Variable	Aquisition of Practical Skills	Developing Motivation	Knowledge in Chemistry	Preparing for Examinations
Teacher Qualification	-0.28 (0.05)	0.13 (0.21)	0.050 (0.38)	0.03 (0.44)
Teacher Gender	-0.11 (0.25)	0.28 (0.13)	-0.19 (0.32)	0.25 (0.06)
Class Size	0.16 (0.16)	-0.19 (0.12	0.32 (0.02)	-0.031 (0.03)
Teaching Load	-0.29 (0.05)	-0.08 (0.31)	0.29 (0.36)	-0.05 (0.38)
Availability of Lab Assistance	0.15 (0.46)	0.13 (0.37)	0.09 (0.29)	-0.14 (0.21)
Teaching Methods Choice	0.36 (0.01)	0.06 (0.37)	0.32 (0.03)	0.04 (0.40)
Student Gender	0.09 (0.16)	0.10 (0.15)	-0.20 (0.02)	-0.02 (0.39)
Student Subject Combination	0.05 (0.63)	-0.23 (0.01)	-0.04 (0.68)	0.20 (0.04)

In brackets is the significance level for a 2-tailed test.

Discussion

Discordance Between Teachers' and Students' Rankings of the Importance of Practical Work Objectives

List of ten objectives

For the list of ten objectives both the frequency and graphical comparisons show general discordance between teachers' and students' rankings of practical work objectives. The disagreement in the rankings of objectives supports the findings of Gunning and Johnstone (1976) and Lynch and Ndyetabura (1983) whose investigations although at middle secondary school level show a mismatch between teachers' and students' rankings of objectives. This might mean that differences between teacher and student perceptions of the purpose of practical work are independent of the secondary school level of the student. While the results of this study support the findings of Lynch and Ndyetabura (1983) and Gunning and Johnstone (1976), the issue of whether or not students and teachers share the same perceptions of practical work objectives is far from being concluded. In a related study, Denny (1986) concluded that teachers' and students' ideas on the purpose of practical work coincide. Table 1.2 shows that teacher and student rankings coincide for the objectives; 1. Be able to draw conclusions from experimental results; 2. Be able to record observations and results; 6. Be able to carry out written and oral instructions, and 9. Be able to design an experiment to investigate a problem.

The high rankings of objectives 1 and 2 by both teachers and students is not suprising given that, part of the A Level Chemistry practical examination is about testing these

objectives. These high rankings might mean that teachers' laboratory teaching implicitly or explicitly place emphasis on student attainment of these objectives as part of examination preparation. Is the learning and teaching of Chemistry all about examinations and certification?

The three objectives ranked lowest by students in this investigation, were also lowly ranked by both teachers and students in the study by Gunning and Johnstone (1976). The objectives are: 10. Develop a sense of curiosity (teachers 8, 10 students), 9. Design an experiment to investigate a problem (teachers 9, students, 9), and 8. Appreciate that there are limitations to accuracy in practical work (teachers 10, students 8). This might point towards cultural factors not being important in influencing student and teacher perceptions of aims of the laboratory. The low ranking of the objective (9) 'developing students' problem solving skills' is concerning because one of the major aims of experiment in science teaching has been taken as the development of problem solving abilities (Solomon, 1988). This low ranking could account for the students' poor performance in the G.C.E practical examination. The examination, tests amongst other things, problem solving skills. Designing an experiment to investigate a problem was ranked lowly by both teachers and students. Perhaps teachers have to put emphasis on attainment of this objective if practical examination results are to improve.

Four Broad Objectives

A consideration of the rankings of the four broad objectives shows that students think a positive attitude towards chemistry is the most important objective of practical work. Teachers think practical work should be for 'teaching concepts' as evidenced by their higher ranking of 'enhancing knowledge.' This confirms the traditional belief

that experiments are for, illustrating theory (Novak, 1976). Perhaps teachers should not be blamed for harbouring such a view as the building of knowledge and understanding of science thorough concrete experiences has been advanced as the major reason for involving students in practical work (Denny, 1986). The question to ask is whether or not teachers are attaining this objective? From the way students ranked this objective it could be suggested that students believe they do not benefit much from experiments in terms of understanding theory. To them the major aim of practical work is to generate interest in the subject. Work by Johnstone and Wham (1982) and reviews by Garret and Roberts (1982) indicate that much of practical work does not help students' understanding of theory. Perhaps teachers do not think maintenance of interest is that important and thus fail to take care of this requirement in their organisation of practical work.

According to Byrne (1990) the consensus view appears to be that practical work mainly achieves acquisition of manipulative skills. When the four major objectives are considered, students think acquisition of manipulative skills is less important than preparation for examinations. Acquiring skills in handling apparatus and chemicals (manipulative skills) was also ranked higher by students than by teachers in the study by Gunning and Johnstone (1976). It could be that 'A' Level teachers believe students have already acquired basic manipulative skills at O Level. Is it possible that teachers take for granted the level of skill mastery of 'A' Level students? Such an assumption is obviously a critical factor in determining 'A' Level candidates' practical work examination performance. It could also be a factor in accounting for the observed student perceptions.

Consideration of Association Between Variables

It was expected that teachers' views on practical work objectives should significantly be correlated with their qualifications. The fact that the majority of teachers who completed the questionnaire have no professional qualification in education could have meant some association. These results mean that professional training has no influence on teacher perception on practical work objectives. This is difficult to believe. Perhaps further investigation with a larger sample can yield a different result. No correlations were found between teacher perception of practical work objectives and teacher gender, teaching load, class size, teaching methods, and availability of lab assistance. According to the findings of Arzi-Ben-Zvi and Ganiel (1984), correlations existed between teachers' judgements of the purpose of practical work and the amount of practical work they gave to their classes. This variable was not investigated here.

The findings of this study support Lynch and Ndyetabura (1983), who found that students' gender differences are not associated with orientation towards practical work objectives. Surprisingly there is also no relationship between students' 'A' Level subject combinations and perception of practical work objectives. It was expected that the way practicals are handled in other subjects should influence students' perceptions of Chemistry practical work objectives.

Conclusion and Implications

This study concluded that, teachers' and students' rankings of the importance of objectives of practical work are completely different from each other and that

teachers' and students' perceptions of practical work objectives are not related to the investigated educational variables.

Of interest is the fact that students associate practical work with the development of interest in the subject and the acquisition of manipulative skills whereas teachers are more interested in using practical work to enhance students' knowledge of chemistry. The responsibility for this difference can be found in the teachers or in the curriculum materials or in both. This study has not been able to pinpoint any specific factor as responsible. Students' perceptions of practical work objectives could be based on covert message transmitted consciously or unconsciously by the teachers. Hashew (1996) points out that there is an underlying assumption that teachers tend to foster attributes in themselves onto their students. The results of this investigation do not fully support that assumption. Student perceptions could perhaps be influenced by other factors in the 'milieu' in which curriculum implementation occurs. It would be interesting to investigate these factors. Replication of the study reported here with larger sample sizes might also yield different results.

In the light of these findings 'A' Level chemistry teachers need to re-examine their instructional strategies for what they think they are achieving is not what happens in reality. Perhaps teachers need to teach practical skills through a deliberate repetition of practical tasks. Repetition of frequent practical tasks leads to development of practical skills that in turn entail achievement of objectives. Continuing to rely on practical work to teach the understanding of theory could be counterproductive, as students do not see practical work as that helpful in achieving that objective. There appears to be a need for teachers to involve students in more problem-solving experimental work in order for the students to appreciate the importance of problem solving as an objective of practical work. An Australian study (Staer, Goodrum &

Hackling, 1998) revealed that teachers are doing little to engage students in open inquiry. The results of this study conform to these findings. Chemistry teacher education in-service curriculum content should also recognise these important observations. Sound 'A' Level Chemistry instructional planning and student evaluations should perhaps, start by a consideration of what students think content and skills training is aimed to achieve. This supports constructivist thinking of building the curriculum and instruction from the prior thinking and knowledge of the learner.

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