EVALUATION OF SCIENCE LABORATORIES IN PALESTINIAN SCHOOLS

KHAWLA SHAKHSHIR SABRI

Abstract – *This study sets out to assess the general situation and practices of the science laboratory activities in the Palestinian secondary and preparatory schools. The article is based on data collected from a select sample of University students who responded to a questionnaire devised by the author. The survey included questions about the use of laboratory activities in the teaching of sciences, as well as about the kind of equipment used and the nature of experiments carried out. The survey shows that the majority (80%) of Palestinian students are exposed to at least one or more science experiment during their period of school study. Less than one third of participants write reports for laboratory activities or receive oral and written feedback for the experiments from the teacher. Furthermore, the survey revealed that there are no significant differences between the experiences of public and private school students concerning the majority (90%) of the science experiments and equipment listed in the questionnaire. On the other hand, important differences do exist when it comes to the conditions of the science laboratory in the two school sectors in Palestine.*

Introduction

The use of science laboratories in secondary and university education, both as an independent model of instruction as well as a teaching tool, has received much attention internationally in the last three decades. Studies have investigated various aspects of teaching in and through science laboratory activities, and have focused on issues such as main objectives, optimal conditions and environment, the technical procedures of using the laboratory in teaching science, methods of student evaluation, the writing of laboratory reports, as well as the assessment of the time-, cost- and learning-effectiveness of the laboratory as a mode for the teaching of science as compared to other modes. Among these studies, one can highlight that carried out by Bound et al. (1980), for instance, which concluded that the most important objective of science laboratory courses is to train scientists in practical work and to develop observational skills. Wilson and Stensvold (1991) and Stensvold and Wilson (1993), on their part, summarised the aims of laboratory instruction in terms of its value in prompting scientific thinking, providing first hand experience, developing practical competence within a safe working

environment, and facilitating the skill of the application of facts to new situations. Additionally, the authors consider the laboratory practical examinations as a sure test of student achievement in the goals just specified. In another important study, Keys (1995) suggested that the writing of laboratory reports helps learners develop the ability to reason scientifically and to progress from the observation of data to a warranted conclusion, especially if this exercise is carried out in the context of collaborative discussions. Focusing on learner perspectives, Metcalf and Wilson (1994) reported that that students tend to perceive laboratory activities in a positive light, considering them to be valuable and worthwhile.

Some research on the use of laboratories in school science teaching has set out to evaluate the efficiency and environment of laboratory activities in general through the use of standard forms and criteria. Other studies, such as that carried out by Fraser et al. (1995) have evaluated the effectiveness of the laboratory as a teaching model in comparison with other instructional methods, as expressed by students' achievements. In this regard, the superiority of the laboratory model is practically uncontested, as a review of the literature shows. Thus, Babikian (1971) found that expository and laboratory methods are significantly more effective than the discovery method for teaching science concepts to eighth grade students. This trend also appears to hold true in Arab schools where it was shown by Zitoon and Al-Zaubi (1986) that the laboratory method was more effective in comparison with the traditional method of teaching in developing the skills of scientific thinking in Jordanian secondary science stream students. Similar findings were reported by Leonard (1983) with reference to biology courses.

Other studies probematise the presumed value of laboratories in the teaching of science. Hofstein and Lunetta (1982), and Lunetta, Hofstein and Giddings (1981) for instance, conclude that laboratory instruction may play an important part in the achievement of some, but not all the stated goals of science education. This is in part due to the fact that generally teachers fail to incorporate laboratory goals within their evaluation system. A further aspect of critical research has focused on the obstacles of using the laboratory in teaching science. For example, Zitoon (1988) identified 22 obstacles which preclude the use of laboratories, among these being crowded laboratory classes, and lack of adequate facilities and financial resources. Keulen et al. (1995) have indicated that textbooks and traditional curricula may lead to the inefficient teaching of laboratory courses. Furthermore, the effectiveness of laboratory teaching may depend on the grouping of students on the basis of their formal reasoning ability (Lawrenz & Munch 1984).

This article sets out to consider a number of the issues just raised with reference to science education in Palestine. Before moving to that substantive

area of inquiry, it is important to provide some background information about the state of general and science education in Palestine, and particularly in the West Bank.

Education in the West Bank

There are three different educational systems in the West Bank. The public (Government) schools constitute about 75% of the student population, including all non-refugee students in the elementary and the preparatory stages, as well as all refugee and non-refugee secondary students. The schools (elementary and preparatory) operated by the United Nations Relief and Works Agency (UNRWA) for Palestinian refugees account for approximately 15% of the West Bank student population. The private sector caters for 10% of the number of students in the West Bank. Females constitute approximately 48% of the student population.

The educational system includes 12 grades, with preschool education remaining outside the realm of the official educational system. Grades 1-9 are compulsory. They are referred to as the 'basic cycle' and include 85% of the total student population. Secondary schools (grades 10-12) cater for 15% of the student population. There are 17 vocational schools and centers. The average number of students per class ranges from 32 to 34 students (Shakhshir-Sabri 1996). School enrollment statistics for the West Bank in 1994 show that the total number of students was 350,131 students distributed amongst 1,390 schools and 10,302 classrooms. This student population was served by 11,290 teachers, 6,069 of whom were female (PCBS, 1995).

Science education in the West Bank

Science courses are taught in all grades with the number of weekly lessons being 4 out of 28 in the elementary grades, and 4 out of 29 in the preparatory grades. At the secondary level, students opt either for a literary or a science stream. The curriculum for the science stream includes courses in Biology, Chemistry, and Physics and account for approximately one third of the 32 weekly lessons. In comparison, the literary stream curriculum includes only three weekly lessons in general science (Shakhshir-Sabri 1996).

Laboratory work in Palestinian schools is considered an extracurricular activity, and is available in about one third of the establishments, mainly public and private schools in cities. Schools with no laboratories have little science equipment and occasionally conduct experiments in the classrooms. Some studies

reported that there is a lack of laboratories in the majority of Palestinian schools, and only 35% of Palestinian secondary schools (nearly 286 schools) have standard laboratories (UNESCO 1990, p.16; Shaheen 1987, p.61). Ahlawat, Billeh & Al-Dajeh (1993) reported that 36% of Palestinian students never carried out science experiments and 10% of students never observed an experiment in their schools. We also know that teachers in the Palestinian public school system perceive the lack of laboratories as a greater problem than do private and UNRWA school teachers (Sabri-Shakhshir 1995). However, none of the above studies has appraised the science school laboratories situation in detail, so that there is no data on the types of experiments conducted, and on other related aspects concerning the use of the laboratory as a model of instruction for science teaching.

The research reported here makes a useful contribution to the literature therefore, and is timely given the recent events in the Middle East, with the Palestinian National Authority acquiring responsibility for the administration of the educational system in both the West Bank and the Gaza Strip. The newly established Ministry of Education within the Palestinian National Authority is currently reevaluating the entire educational system in order to create a new set-up which will be more responsive to Palestinian identity and aspirations. In this respect, this study could be considered as an activity within the global evaluation of the educational system within Palestine. Specifically it considers the science laboratory as an instructional model, as well as the conditions of science laboratories in Palestinian schools in general and in public and private schools in particular. The study therefore has the following goals:

- To disclose the state of affairs in science laboratories, as these are perceived by Palestinian students, and including information about how experiments are conducted, reports are written, and work evaluated and graded in both public and private schools;
- To identify and rank-order the science laboratory equipment that is most in use in Palestinian schools in general, and to disaggregate the data on the basis of type of school, i.e. whether private or public institutions;
- To identify and rank-order the most common laboratory experiments in Palestinian schools in general, and again to see whether there are differences between private and public schools;
- To determine the differences between the experience of private and public school students in the science laboratories.

Hypotheses

A number of hypotheses were examined in this study. First, it was hypothesised that no significant differences exist between the science laboratory

experiences of public and private school students, and in the nature of science experiments conducted in the two sectors. It was also hypothesised that there are no significant differences in the science laboratory equipment found in public and private schools.

Methodology

Developing the instrument

Data were collected by means of a four-section survey instrument developed by the author for the purpose. A first section gathers general information about the participant and the type of school (s)he is enrolled in. It should be mentioned here that UNRWA schools were excluded from the study because they do not serve the secondary population of students. Section two consists of eight questions designed to tap information about laboratories in Palestinian schools, and specifically investigate the organisation of the laboratory, student participation in conducting experiments, and the writing and grading of reports. Section three inquires about the type of equipment used in the school laboratories. Questions in this section were formulated after a thorough examination of the science textbooks used in the target schools, and an appraisal of the extra-curricular science activities assigned there. An initial list of 25 items was shown to a sample of science teachers. These were asked to critique the schedule and to suggest modifications to it. Based on the teachers' comments, a final list of the most basic items needed for the science curriculum (general science, physics, chemistry, and biology) was made. The fourth and final section of the questionnaire consists of a list of 15 experiments divided equally amongst the three subjects of chemistry, physics, and biology. This list was drawn up on the basis of the opinions and recommendations of a sample of 30 science teachers, and with reference to the official textbooks and syllabi in use in schools.

Population and sample

All secondary school science stream graduates (N = approximately 3000) in the West Bank constituted the population from which the sample for this study was drawn. A random sample of 120 freshmen students representing all districts of the West Bank and enrolled in laboratory courses at Birzeit university in 1995 made up the sample. A total of 40 students was chosen from each laboratory groups of physics, biology and chemistry. 80 of the students came from public schools while the other 40 graduated from private schools.

Procedure

The questionnaire was distributed to the selected students during their laboratory classes. Students generally took about 20 minutes to address all the items. 18 questionnaires were discarded due to errors, and this left 102 valid returned responses from 68 students who attended public schools and 34 students who attended private schools. Responses were calculated and tabulated according to rank and percentage of the total number of participants. Responses to the items on sections three and four were tabulated according to percentages of the total and for each type of school. Chi-squares were calculated for the contingency tables to determine significance level.

Results

Conditions and practices in the laboratories

All respondents stated that laboratory equipment existed in their schools, although only 41% said that this equipment was located in standard laboratory rooms divided into sections for chemistry, biology and physics. While 80% of the students have observed one or more science experiments in their schools, only 45% participated in conducting them and 38% performed the experiments alone under the supervision of the teacher. 35% of the respondents wrote a laboratory report, of whom 31% received oral or written feedback and 27% received grades.

A closer examination of the results reveals that private schools are better off than public ones given, that half of the students in the former establishments stated that their schools had standard laboratory rooms divided into sections for the different sciences. This was only true for 37% of students from public schools. 91% of the private school students had observed laboratory experiments and 51% had conducted one compared with 80% and 38% respectively for the public school students. Similar advantages were noted for private school students compared with public school students regarding writing, evaluating and grading, as can be seen in Table 1.

Equipment used

Table 2 depicts the laboratory equipment that is most used. It shows that the microscope, test tube, compass, beaker, and spring balance were identified by 90% or more of the respondents as available in the schools they had attended. The rank of equipment identified by public school students differs from that of the public school students, and this difference emerges clearly in Table 3. Although

TABLE NO. 1: Conditions of school science laboratories as reported by Palestinian students

Statements Related to Science Laboratories	Total %	Public %	Private %
Is there science lab equipment in your school?	100%	100%	100%
Is there a standard lab room divided into sections (chemistry, physics, biology) in your school?	41%	37%	50%
Did you observe a science experiment in your school?	80%	75%	91%
Did you participate with your teacher in preparing any science experiments?	45%	40%	54%
Did you conduct a science experiment by yourself?	38%	31%	51%
Did your lab teacher ask you to write an experiment report you made or observed?	35%	28%	50%
Did the teacher give written or oral feedback on your lab report?	31%	23%	47%
Did the teacher give a grade on your lab report ?	27%	20%	41%

the top and bottom five items were ranked similarly by both groups, some items received different rankings. For example, while the barometer was identified by 50% of public students, it was identified by only 29% of private school students. Similar findings were observed for the sphygmomanometer (37% for public, 58% for private), and dissecting instruments (43% for public, 77% for private).

TABLE NO 2: Rank of the listed science laboratory equipment used by students during their secondary studies in Palestinian schools

Name of the Equipment		Identified by Students	
1	Ammeter	69%	9
2	Voltmeter	64%	12
3	Barometer	43%	17
4	Thermometer	78%	7
5	Resonating forks	53%	13
6	Micrometer	45%	15
7	Sphygmomanometer	44%	16
8	Centrifuge	24%	20
9	Dissecting Tools: Scalpel, Tweezers	48%	14
10	Verifier	36%	18
11	Compass	96%	3
12	Microscope	100%	1
13	Analytical Balance	69%	9
14	Spring Balance	90%	5
15	Burette	69%	9
16	Pipette	70%	8
17	Beaker	95%	4
18	Test Tube	99%	2
19	Crucible	35%	19
20	Bunsen Burner	81%	6

TABLE NO 3: Rank of listed science laboratory equipment as identified by students during their studies according to type of school

Science Laboratory Equipment		Public		Private	
		Ratios	Ranks	Ratios	Ranks
1	Ammeter	63%	9	61%	12
2	Voltmeter	58%	12	55%	15
3	Barometer	50%	14	29%	18
4	Thermometer	78%	6	74%	10
5	Resonating forks	52%	13	58%	13
6	Micrometer	48%	15	38%	17
7	Sphygmomanometer	37%	18	58%	13
8	Centrifugal machine	27%	20	20%	20
9	Dissecting tools-scalpel, tweezers	43%	16	77%	8
10	Venire	40%	17	39%	16
11	Compass	100%	1	93%	5
12	Microscope	100%	1	97%	1
13	Analytical balance	65%	8	68%	11
14	Spring balance	87%	5	94%	2
15	Burette	62%	10	77%	8
16	Pipette	60%	11	87%	6
17	Beaker	88%	4	94%	2
18	Test tube	98%	3	94%	2
19	Crucible	33%	19	26%	19
20	Bunsen burner	72%	7	81%	7

Most commonly-conducted experiments

Table 4 shows that the most commonly performed science experiments in secondary schools are those on lenses (concave and convex), the reaction of sodium with water, forming images in straight and concave mirrors, closed and open electric circuits, and sound experiments. These experiments were mentioned by at least two-thirds of the students. Experiments on changing potassium chromate to potassium dichromate, dissecting animals, studying the model of the human ear, the reaction of hydrochloric acid with silver nitrate, checking for carbohydrates in potato and bread, and mechanical experiments were mentioned by 24% – 54% of the students.

Examination of the data (See Table 5) also revealed that of the five most commonly-conducted experiments, four were in physics (54%-81%), one in chemistry (24%-81%), and none in biology (36%-60%). This variance could be explained by the fact that physics experiments are easier and less costly to run compared with the counterparts in chemistry and biology. For example to run a sound experiment is easier than dissecting a frog. There does not appear to be any differences in the most and least ranked experiments between private and public schools; indeed, there was total congruence between the two groups. Public schools, however, conducted experiments on forming images in straight and concave mirrors and mechanical machines more than the private schools. Experiments such as acid-base titration, changing potassium chromate to potassium dichromate, the reaction of sodium with water, dissecting animals, and the reaction of hydrochloric acid with silver nitrate were performed with greater frequency in the private schools.

Experiences of public and private school students

As can be seen from Table 6, public and private school students perceived the conditions of their secondary school science laboratories differently. There is a significant difference in the experiences in science laboratories between public and private students concerning the following conditions of school science laboratories:

- The standard lab room divided into sections (chemistry, physics, biology).
- Making a science experiment by the student himself/herself.
- The lab teacher asking students to write an experiment report.
- The teacher giving written or oral feedback on students' lab report.

TABLE NO. 4: Rank of the listed science laboratory experiments as used by the students throughout their studies in schools

No.	Science Laboratory Experiments	Ratios	Ranks
1	Electrolysis of water	63%	7
2	Acid base titration	64%	6
3	The reaction of hydrochloric acid with silver nitrate	51%	12
4	Chemical equilibrium: changing potassium chromate to potassium dichromate and vice versa	24%	15
5	The reaction of a piece of sodium with water	81%	1
6	Dissecting an animal like a frog or a rabbit	36%	14
7	Preparing a slide of onion peel and seeing it under the microscope	57%	9
8	To check for carbohydrates in potato and bread	54%	10
9	Study of the model of a human ear	51%	12
10	Experiments on osmosis phenomena and osmosis pressure	60%	8
11	Experiments on the closed and open electric circuit	68%	4
12	Experiments on convex and concave lenses	81%	1
13	Experiments on forming images in straight and convex mirrors	74%	3
14	Sound experiments using the resonating (tuning) fork	67%	5
15	Mechanical machines like Pulley, Lever, Crane & Nutcracker	54%	10

TABLE NO 5: Rank of listed science laboratory experiments as identified by the students throughout their studies in schools based on type of school

Science Laboratory Experiments		Public		Private	
		Ratio	Ranks	Ratio	Ranks
1	Electrolysis of water	63%	6	58%	9
2	Acid base titration	57%	7	77%	2
3	The reaction of hydrochloric acid with silver nitrate	43%	12	61%	7
4	Chemical equilibrium: changing potassium chromate to potassium dichromate & vice-versa	18%	15	32%	15
5	The reaction of a piece of sodium with water	65%	4	81%	1
6	Dissecting an animal like a frog or a rabbit	27%	14	55%	13
7	Preparing a slide of onion peel and seeing it under the microscope	53%	11	58%	9
8	To check for carbohydrates in potato and bread	43%	12	58%	9
9	Study of the human ear through the use of a model	57%	7	65%	5
10	Experiments on osmosis phenomena and osmosis pressure	55%	10	58%	9
11	Experiments on the closed and open electric circuit	65%	4	61%	7
12	Experiments on convex and concave lenses	75%	1	74%	3
13	Experiments on forming images in straight and concave mirrors	75%	1	65%	5
14	Sound experiments using the resonating (tuning) fork	67%	3	68%	4
15	Mechanical machines like Pulley, Lever, Crane & Nutcracker	57%	7	45%	14

TABLE NO. 6: Comparison between Public and Private school students' perception of the conditions of science laboratories

Statements related to Science Laboratories	Chi-square	Significance
Is there science lab equipment in your school ?	1.64	No Significance (n. s.)
Is there a standard lab room divided into sections (for chemistry, physics, biology) in your school?	3.76	.05
Did you observe a science experiment in your school ?	1.61	n.s.
Did you participate with your teacher in preparing any science experiments ?	3.54	n.s.
Did you conduct a science experiment by yourself ?	4.15	.04
Did your lab teacher ask you to write a report on an experiment you made or observed ?	6.69	.01
Did the teacher give written or oral feedback on your lab report ?	4.82	.02
Did the teacher give a grade on your lab report ?	3.54	n.s.

Accordingly, the stated null hypotheses have been rejected for the above listed conditions of science laboratories in the Palestinian school, which means that the above conditions of science laboratories in private schools are better than in public schools. On the other hand, the null hypotheses concerning other listed statements have been retained.

Table 7 compares public and private secondary schools in terms of available equipment. It shows clearly that very little difference could be detected between the two groups; dissecting tools and pipettes being the only two pieces of laboratory equipment achieving statistical significance between the two groups. Accordingly the stated null hypotheses regarding the 18 items of the laboratory equipment have been retained.

TABLE NO 7: Comparison between students' experience of listed science laboratory equipment in Palestinian Private and Public Schools

Equipment List		Chi-square	Significance
1	Ammeter	.02	n.s.
2	Voltmeter	.02	n.s.
3	Barometer	3.34	n.s.
4	Thermometer	24	n.s.
5	Resonating	.32	n.s.
6	Micrometer	.72	n.s.
7	Sphygmomanometer	2.86	n.s.
8	Centrifugal machine	.42	n.s.
9	Dissecting tools: Scalpel, Tweezers	10.43	.001
10	Verifier	.02	n.s.
11	Compass	3.25	n.s.
12	Microscope	2.01	n.s.
13	Analytical balance	.09	n.s.
14	Spring balance	1.27	n.s.
15	Burette	2.21	n.s.
16	Pipette	9.11	.002
17	Beaker	1.27	n.s.
18	Test Tube	.11	n.s.
19	Crucible	.37	n.s.
20	Bunsen Burner	.64	n.s.

TABLE NO 8: Test of significant difference between the Palestinian Public and Private students' experience concerning the listed science laboratory experiments

	Science Laboratory Experiments	Chi-square	Significance
1	Electrolysis of water	.19	n.s.
2	Acid base titration	4.11	.04
3	The reaction of hydrochloric acid with silver nitrate	3.31	n.s.
4	Chemical equilibrium: changing potassium chromate to potassium dichromate & vice versa	2.81	n.s.
5	The reaction of a piece of sodium with water	2.75	n.s.
6	Dissecting an animal like a frog or a rabbit	8.48	.003
7	Preparing a slide of onion peel and seeing it under the microscope	.32	n.s.
8	To check for carbohydrates in potato and bread	2.37	n.s.
9	Study of the human ear through the use of a model	.33	n.s.
10	Experiments on osmosis phenomena and osmosis pressure	.18	n.s.
11	Experiments on the closed and open electric circuit	.08	n.s.
12	Experiments on convex and concave lenses	.03	n.s.
13	Experiments on forming images in straight and concave mirrors	.62	n.s.
14	Sound experiments using the resonating (tuning) fork	.02	n.s.
15	Mechanical machines like Pulley, Lever, Crane & Nutcracker	1.6	n.s.

Similar findings were noted regarding the differences between the two groups in the experiments they conduct. This is reflected in Table 8, which shows that the dissection of animals and acid-base titration experiments were the only items showing statistically significant differences. There is no significant difference between the experience of private and public students concerning the majority of the listed experiments. Accordingly the stated null hypotheses regarding the other 13 items of the laboratory experiments have been retained.

Summary and conclusions

The purpose of this study was to explore and evaluate science laboratory activities in Palestinian schools, on the basis of the experiences and perceptions of freshmen Palestinian university students. The selected participants were asked to identify listed science laboratory practices, equipment and experiments, based on their experience in schools.

The study revealed the following conclusions:

- The majority (80%) of Palestinian students were exposed to at least one or more science experiments during her/his secondary education.
- Less than one third of the participants wrote reports for laboratory activities or received oral and written feedback from their teachers on their achievement.
- Less than one half (41%) of the participants stated that their schools had a standard laboratory room.
- The science laboratory situation in private schools is better than in public schools in terms of the number of observed experiments, participation in the experiments, writing of laboratory report, and evaluation and grading of the report.
- Experiments appear to be most often conducted in Physics, and least often conducted in Biology.
- The majority of the public school students identified 11 of the experiments listed in the questionnaire, while the majority of private school students identified 13.
- The maximum percentage of listed experiments identified by students was 81%, and the minimum was 24%.
- There were more private than public school students who reported that they had observed or participated in science laboratory experiments.

- There is no significant difference between the experience of public and private school students concerning the majority (90%) of the listed experiments and equipment.
- There is a significant difference between the experience of public and private school students concerning half of the conditions of the science school laboratory in the Palestinian schools.

It is assumed that the above findings are of interest to scholars of comparative science education, and of particular relevance to Palestine as it sets about the challenging task of reforming its educational system. It is clear, for instance, that special attention should be given to the opening of science laboratory rooms in all secondary schools, to the reorganisation of the present laboratory rooms, to the formulation of instructions related to the evaluation process in the laboratory class, and to the adequate coverage of practical, observational and theoretical as well as of cognitive, psychomotor and affective domains. The evaluation process should include the appropriate method of writing laboratory reports, teachers' feedback and grades, and the laboratory activities to be adopted in order to improve the laboratory as an instruction model for the teaching of science.

Khawla Shakhshir Sabri *is the chairperson of the Education Department and Director of the Masters Programme at Birzeit University. Address for correspondence: 14 Birzeit, West Bank, Palestine. Tel. 9722-9957650-4. Fax. 9722-9957656. Email.<Nsabri@admin.Birzeit.edu>.*

References

Ahlawat, K., Billeh, V. & Al-Dajeh, H. (1993) *Student Achievement in Jordan and the West Bank: A Comparative Respective.* Jordan: NCERD.

Bound, D., Dunn, J., Kennedy, T. & Thorley, R. (1980) The aims of science laboratory courses: a survey of students, graduates and practicing scientists, *European Journal of Science Education,* No.4, pp.416-429.

Babikian, Y. (1971) An empirical investigation to determine the relative effectiveness of discovery, laboratory, and expository methods of teaching science concepts, *Journal of Research in Science Teaching,* Vol.8(3), pp.201-209.

Fraser, B., Geoffrey, J., Giddings, J., Campbell, J. & McRobbie, J. (1995) Evaluation and validation of a personal form of an instrument for assessing science laboratory classroom environments, *Journal of Research in Science Teaching,* Vol.32(4), pp.399-422.

Hofstien, A. & Lunetta, V. (1982) The role of the laboratory in science teaching: neglected aspects of research, *Review of Educational Research,* Vol.52(2), Summer pp.201-217.

Keys, C.W. (1995) An interpretive study of students' use of scientific reasoning during a collaborative report writing intervention in ninth grade general science, *Science Education,* Vol.79(4), pp.415- 435.

Keulen, H., Mulder, T, Goedhart, M. & Verdonk, A. (1995) Teaching and learning distillation in chemistry laboratory courses, *Journal of Research in Science Teaching,* Vol.32(7), pp.715-734.

Leonard, W.H. (1983) An experimental study of a BSCS-style laboratory approach for University general biology, *Journal of Research in Science Teaching,* Vol.20(9), pp.807-813 .

Lawrenz, F. & Munch, T.W. (1984) The effect of grouping of laboratory students on selected educational outcomes, *Journal of Research in Science Teaching,* Vol.21(3), pp.699-708.

Lunetta, V.N., Hofstein, A. & Giddings, G. (1981) Evaluating science laboratory skills, *The Science Teacher,* Vol.48(January), pp.22-25.

Metcalf, K. & Wilson, M. (1994) Improving the efficacy of on-campus laboratory experience using the MYERS-BRIGGS type indicator, *Journal of Research and Development in Education,* Vol.27(2), pp.89-100.

PCBS (1995) *Educational Statistics In the West Bank and Gaza Strip.* PCBS Report No. 5 (August), pp.129-132.

Shaheen, M.Abd-Fattah (1987). *The Situation of the Primary and Secondary Education in the West Bank.* Hebron: Universities Graduates Association.

Sabri, K.S. (1995) The existing educational problems during the Intifada as perceived by the Palestinian teachers, *Journal of Drassat (The Research Journal of Jordan University),* Vol.22(2) April.

Sabri, K.S. (1996) *The Education System in the West Bank and Gaza Strip.* Geneva: UNCTAD.

Stensvold, M. & Wilson, J. (1993) A method of designing practical examinations to match what is taught in laboratory activities, *School Science and Mathematics,* Vol.93(3), May, pp.250- 252.

UNESCO (1990) *The Assessment of Needs for the Palestinian People in Education and Training.* Paris:UNESCO.

Wilson, J. & Stensvold, M. (1991) Improving laboratory instruction: an interpretation of research, *Journal of College Science Teaching,* Vol.20(6), pp.350- 353.

Zitoon, A. (1988) The attitudes and obstacles of using the laboratory by science teachers in the preparatory schools, *Journal of Drassat,* Vol.15(8), pp.187- 201.

Zitoon, A. & Al-Zaubi, T. (1986) The effect of using laboratory on developing science thinking skills of 11th Grade students in Jordan, *Journal of Education,* Vol.3(9), pp.94-117.