The Contributions of Enrichment Activities Towards Science Achievement*

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ABSTRACT

This study investigated whether enrichment activities would improve achievement in science.

One hundred and eighty subjects took part in the study. They were assigned to two experimental, two control and one Hawthorne control groups. Experimental subjects participated in enrichment activities held outside the school. Control subjects were not given these activities while the Hawthorne control group was taken out on excursions unrelated to their science lessons.

The Cooperative Science Test (COST) was used to assess the acquisition of science concepts while science achievement was based mainly on school science examination scores.

The results indicated that the experimental subjects showed significantly greater improvement in concept attainment and science achievement. Correlations between science concept attainment and science examination scores were positive and significant.

The study concluded that participation in enrichment activities relevant to school science would improve science achievement.

Introduction

It is becoming increasingly important that children be able to understand basic science principles and to relate these to everyday life. The focus is on how to teach the subject so that it makes sense to the students, stimulates their curiosity, interests them in examining some of the perplexing situations in their surroundings, and guides them in solving problems scientifically.

Current trends in science teaching favour a move away from classroom chalk and talk, and from laboratory exercises that tend to merely demonstrate scientific principles. The recent wave of interest in non-formal education has made many realise that a meaningful education experience must be a mix of in-school and out-of-school processes. Until recently, out-of-school enrichment programmes received little attention in Singapore (Chang, 1974; Bhathal and Tian, 1979; Harrison, 1979; Lee, 1979; Ng, 1979; Rao, 1980). Supplementary science activities were left largely to school science clubs, and were treated by many students as extramural rather than an essential part of their science learning (Chang, 1974). Many teachers thought that students were just as well off staying and learning in schools.

Harrison (1979), Rao (1980) and Yeoh (1980) urged schools to expand their scope beyond their walls and to provide students with access to other knowledge resources. This is especially important in keeping up with the changes in the science syllabi which have been revised to suit the needs of local students.

The Lower Secondary Science (LSS) syllabus (Cheah, 1981) is not made up of discrete components of physics, chemistry and biology. It provides for an integrated treatment

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of science topics utilizing the thematic approach and cutting across the boundaries of all science subjects. LSS advocates a change from purely fact-centred to enquiry-based and activity-oriented science teaching. It reflects an important shift in emphasis, the main objective being to provide opportunities for students to be innovative in their learning, and science course that is both meaningful and relevant in terms of our increasingly technological environment. It is difficult to achieve these objectives from the lessons taught in schools alone.

Experience has proven that out-of-school supplementary activities are an important corrective compensation for some of the shortcomings in formal education (Stevens, 1969). Within-school and out-of-school experiences are complementary and through their merger, teachers can better help their students to understand scientific concepts.

There are in Singapore several learning resources offering out-of-school educational experiences. The Botanic Gardens, Jurong Bird Park, Coralarium, Singapore Zoological Gardens and the Van Kleef Acquarium are concerned with the biological sciences. Their programmes are however not fully complementary with the Lower Secondary Science syllabus. The Singapore Science Centre runs a comprehensive set of specially prepared educational programmes which can be tailored to the school's needs. Moreover, its exhibits are presented in a thematic fashion which blends well with the themes covered in the Lower Secondary Science syllabus. Hence the Singapore Science Centre was chosen for this study.

Exposure to concepts is said to be controlled by the teacher through the use of activities which could differ in kind and setting but all would have the common purpose of stimulating learning (Jenkins, 1969; Wright, 1980). Experimental research (Sunal, 1976; Holliday, 1980) has also suggested that concrete and visually oriented teaching procedures are effective in teaching concepts. Studies in the museum setting and reports such as those by Kimche (1978) and Wright (1980) have indicated the effectiveness of multisensory hands-on experiences in assimilating and applying complex concepts and in heightening the acquisition and retention of knowledge. Furthermore, Wright (1980) found increased learning of factual knowledge through museum experiences that were integrated with class lessons. These findings suggest that teachers should give their students a variety of experiences which fully involve most or all of the senses.

Chang (1974) demonstrated in her study that innovative teaching strategies and the provision of well-planned science enrichment activities positively influenced performance in the subject. She noted that any educational experience must bear relevance to what the students already know. The activity could then be assimilated into some schematic whole which would be given significance only if it had meaning for the individual (Babikian, 1971; Kolodity, 1977; Wright, 1980).

Studies by Kuhnen (1960), Chang (1974) and Disinger and Mayer (1974) showed that an appropriate combination of teaching methods would result in a number of pay-offs in terms of gain scores. Achievement results appeared to be superior to those obtained when only one medium of instruction was employed. Kolodity (1977) and Linn (1980) also suggested that exposure to materials and activity-centred strategies themselves would not be as effective as when they were used to complement direct instruction.

Field trip studies by Falk, Martin and Balling (1978), and Sneider, Eason and Friedman (1979) showed that students did not benefit from structured, educational programmes that called for the learning of facts or concepts during trips to novel settings. Falk and Balling (1980), and Martin, Falk and Balling (1981) explained that stimuli from novel settings could slow down the learning of concepts. This has implications for teachers with regard to the use of informal experiences. If conceptual learning is desired from a field-trip, it would be advisable to take preparatory measures, such as providing instructions in advance or to familiarize students with the environment. Children want to explore new environments but may lack the right strategies to do so.

Based on the findings of previous studies, the following hypotheses were formulated for testing in this study:

(1) Students who receive structured science enrichment activities would show greater improvement in science concept attainment compared to pupils who do not receive these activities.

(2) Students who receive structured science enrichment activities would score better in the school science examination compared to those students who do not receive these activities.

Metholodogy

SAMPLE

All the 180 students were drawn from a government girls' school *(Express stream). Five intact Secondary Two Classes were selected from among nine of that grade level. The mean age of the students was 13 years 5 months.

Randomisation of individual students was not possible as the composition of existing classes could not be disturbed. The use of intact classes caused minimum disruption to the school programme.

To demonstrate that the intact classes were of comparable ability, the students' 1984 mid-year science examination marks were examined. An analysis of variance was carried out on the mid-year scores and Table 1 shows that the five groups were not significantly different.

At the time of the experiment, all students were taught by the same female science teacher. Hence the teacher variable (in school) was controlled.

The knowledge that an experiment was under way was withheld from the students. The five groups were initially told that they would go on excursions to the Singapore Science Centre sometime in September. However, in the course of the experiment, all control groups were told that their turn to join in the programme at the Science Centre would come later.

TABLE 1 — ONE-WAY ANOVA OF 1984 MID-YEAR SCIENCE EXAMINATION SCORES

Class	Group	Type			
P	1	Experimental	36	62.00	8.96
Q	2	Control	36	62.89	9.34
R	3	Experimental	36	61.89	7.53
S	4	Control	36	60.75	11.28
T	5	Hawthorne Control	36	57.14	8.18

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F-Ratio	p
Among samples	4	730.94	182.73	2.18	N.S.
Within replications	175	14642.20	83.67		
Total	179	15373.10			

* NOTE:
EXPRESS STREAM: Students in the Express Stream are expected to finish their secondary schooling in four years but they can only take one First Language.

DESIGN OF THE EXPERIMENTAL INVESTIGATION

A five-group experimental design was employed. By drawing lots, each of the five intact classes was randomly assigned to and treated as separate experimental units (refer to Table 2).

All students received the same instructions during their in-school sessions. The scope, content and general teaching conditions were kept as similar as possible in all the five groups. Science periods consisted of the conventional lessons, weekly laboratory practical and E.T.V. sessions. The teacher followed the curriculum guide of the LSS syllabus. Audio-visual aids were limited to the use of the chalkboard, charts and others as recommended in the syllabus guide.

The experimental and control groups differed mainly in the following aspects:

(1) the experimental Groups 1 and 3 (P, R) were treated to planned science enrichment activities at the Science Centre.

(2) no extra activities were given to control Groups 2 and 4 (Q, S).

(3) the Hawthorne Control Group 5 (T) received activities unrelated to their school science course. The activities represented an intervention that was not anticipated to have specific effects related to those of the treatment being evaluated. This intervention was deliberately introduced to create the Hawthorne effect which is often associated with a treatment.

The experimental and Hawthorne control conditions were comparable in that both could be expected to produce a Hawthorne effect since both included an intervention.

THE ENRICHMENT ACTIVITIES

The enrichment activities took place in the final (fourth) academic term of 1984 when the school's extra curricular activities programme was almost over.

Table 3 maps out the work schedule for both experimental and control groups.

Prior to each visit to the Science Centre the science teacher carried out lessons relevant to the forthcoming activity since the activities were specially designed to dovetail with in-class work.

A teacher's instructional manual was also prepared. It embodied guidelines for the teacher, and a list of learning outcomes or performance objectives which were stated in terms of concrete, observable behaviours. Provision was also made for students to use their out-of-school learnings in follow-up activities.

After each visit, worksheets and evaluation forms were issued to all students to assess the learning progress and the effectiveness of each lesson. The experimental groups received a total of 12 hours of enrichment programme.

Students in the Hawthorne control group were also treated to five excursions, but the activities were not related to school science lessons. A total of 11.5 hours were spent on these activities.

INSTRUMENTATION

The Co-operative Science Test (COST) (Educational Testing Service, Princeton, 1963) was employed to assess the attainment of science concepts. This test carried 33 multiple-choice questions on biology, chemistry and physics.

TABLE 2 — DESIGN OF THE EXPERIMENTAL INVESTIGATION

Class	Group or Unit	Purpose of Group	Pre-test	Treatment	Post-test
P	1	Experimental	O_1	X_2	O_2
Q	2	Control	O_3		O_4
R	3	Experimental		X_2	O_5
S	4	Control			O_6
T	5	Control (Hawthorne control)	O_7	X_2	O_8

TABLE 3 — WORK SCHEDULE

1984 Calendar	Themes Covered in School	Activities at Singapore Centre: Themes	Activities at Singapore Centre: Modes	Excursions for Hawthorne Control Group	Data Collection
Term 3					
Week 7	Light				
8	Light				
9	Electricity				
10	Electricity				
1 week school vacation				Talk/film show Judy Blume. (2.5 hours)	Pre-test: COST*
Term 4					
Week 1	Ecology	Pond Ecology (3 hours)	Film show, slide, show, lecture, field work, lab work, gallery tour.	Photographic Exhibition (2 hours)	
2	Energy Light	Light and Energy (3 hours)	Lecture-demonstration, film show, gallery tour.	Service Day at St. John's Home for the Aged (2.5 hours)	
3	Electricity	Electricity (2 hours)	Lecture-demonstration, film show, lab work.		
4	Water and Solutions	Diffusion and Osmosis (2 hours)	Film show, lab work.	Shahab Weaving and Batik Printing Factory (2.5 hours)	
5	Acids, Bases and Salts	Catalysis, Chemicals We Eat and Drink (2 hours)	Film show, lecture, slide show	Visit to the Society for the Prevention of Cruelty to Animals (2 hours)	
6					Post-test: COST
10					School final term science examination results

Note *COST — Co-operative Science Test (Instrument)

Questions testing knowledge, comprehension and application skills were set in the ratio of 1:1.4:2.3. The lowest possible score was 0 and the highest possible score was 33. The adapted COST used in the study was trial-tested on two occasions. The Reliability Coefficient (KR_{20}) was found to be 0.61.

The 1984 final term school science examination scores were used to determine students' achievement in science. These were the overall scores as well as the scores of selected items which were relevant to the study. The two-hour examination paper was made up of two sections. The first section was compulsory with 35 multiple-choice items and five structured questions. The second section allowed a choice of four out of five essay questions, each with a weighting of 10 marks. The maximum possible score was 100 and the minimum score zero. The overall score was not solely relied upon because if it was influenced by questions unrelated to the study, it would mask the effects of the enrichment activities on students' performance in the examination. The overall score was used for further verification. The examination paper was vetted by a team of three science teachers and marked by two LSS teachers, each responsible for separate sections of the paper.

Results

SCIENCE CONCEPT SCORES

To evaluate the hypotheses stated earlier, data obtained from the pre- and post-tests and the final term school science examination were analysed. The accepted level of significance was set at 0.05.

The mean and standard deviations of scores for the respective groups are listed in Table 4.

At the start of the experiment, the comparability of three of the groups was further checked by performing a one-way analysis of variance on their pre-test scores. This is shown in Table 5. The calculated F-ratio (2,105) of 0.51 was less than the critical F of 3.09 at the 0.05 significance level. This showed that there was no initial significant difference among the groups with respect to science concept attainment, as measured by COST.

COST post-tests mean scores from four groups were also treated with a two-way 2 × 2 analysis of variance technique to assess the effects of science enrichment activities and of pre-testing (refer Table 6).

The F-ratio (1,140) obtained with regard to the treatment indicated that experimental Groups 1 and 3 achieved significantly ($p < 0.05$) higher scores than the control Groups 2 and 4. The calculated ratio, 6.60, exceeded the critical value of 3.91 (degrees of freedom equal to 1 and 140) at the 0.05 significance level. This F-ratio, though not large enough to be significant at the 0.01 level, was quite close to the critical value (6.83).

TABLE 4 — DESCRIPTIVE STATISTICS OF SUBJECTS' COST SCORES

Variable	Mean	Std. Dev	Variance	Std Error of Mean	Coeff of Variation
Gp 1, pre-test	17.83	3.88	15.06	0.65	21.76
Gp 1, post-test	20.94	3.31	10.97	0.55	15.81
Gp 2, pre-test	18.75	3.63	13.16	0.60	19.35
Gp 2, post-test	19.81	3.55	12.62	0.59	17.94
Gp 3, post-test	21.92	3.77	14.25	0.63	18.05
Gp 4, post-test	18.89	4.11	16.90	0.69	21.76
Gp 5, pre-test	18.31	4.03	16.28	0.67	22.04
Gp 5, post-test	19.14	3.70	13.72	0.62	19.36

TABLE 5 — ONE-WAY ANOVA OF SUBJECTS' COST PRE-TEST SCORES

Group	Type	Size	Mean	Std. Dev
1	Experimental	36	17.83	3.88
2	Control	36	18.75	3.63
5	Hawthorne control	36	18.31	4.03

Source of Variation	Degrees of Freedom	Sum of Squares	Mean of Squares	F-Ratio	p
Among samples	2	15.13	7.56	0.51	N.S.
Within replications	105	1557.39	14.83		
Total	107	1572.52			

TABLE 6 — TWO WAY ANOVA OF COST POST-TEST SCORES

Source of Variation	Degree of Freedom	Sum of Squares	Mean of Squares	F-Ratio	p
Among Samples					
Factor 1	1	8.07	8.07	.59	N.S.
Factor 2	1	90.27	90.27	6.60	0.05
Interaction	1	7.09	7.09	.52	N.S.
Within Replications	140	1915.82	13.68		
Total	140	2021.26			

FACTOR 1	Factor 2		
		Enrichment Activities	No enrichment Activities
	Pre-	Group 1	Group 2
	No Pre-Test	Group 3	Group 4

The F-ratio of 0.59 obtained with respect to pre-testing showed that the effect was non-significant, implying that an exposure to a preliminary test gave no advantage to Groups 1 and 2 in post-test scores. This verified the students' replies that they could not recall questions from COST, a week after taking the pre-test.

The effect of interaction between pre-testing and treatment was also found to be negligible. The F-ratio for this factor, 0.52, was less than the critical value of 3.91 at the 0.05 significance level.

A t-test was again used to test the significance of the differences of the means between pre- and post-test data for Groups 1, 2 and 5. Table 7 reveals that Group 1 had performed significantly better ($p < 0.001$) when COST was administered to them a second time. Groups 2 and 5 did not make significant gains in their post-test scores. Thus, the differences in attainment of science concept scores between pre- and post- tests for these two control groups were negligible.

This was an indication that participation in science enrichment programmes did contribute towards improving science concept attainment, as assessed by COST.

TABLE 7: COST: COMPARISON OF PRE- AND POST- TEST SCORES (DEGREES OF FREEDOM = 70)

Study Units	t-value obtained	α^{t}critical. = 0.05 one-tailed test	α^{t}critical. = 0.001 two-tailed test	p
Group 1	3.61	1.67	3.45	0.001
Group 2	1.23	1.67		N.S.
Group 3	0.90	1.67		N.S.

Table 8 provides the results of an orthogonal comparison to evaluate the difference between mean post-test scores of Groups 1 and 3 as against all the control Groups 2, 4 and 5 combined. The resulting F (1,178) was 8.71, significant at the 0.01 level.

The mean score for the experimental groups was significantly higher than that of the control units. This affirmed the hypothesis that science enrichment activities would aid in the acquisition of science concepts.

Using a one-way analysis of variance to determine the effects of maturation and history, the means of pre-test scores of Groups 1, 2 and 5, and the post-test scores of Group 4, were found to be statistically non-significant. Table 9 gives the calculated F (3,140) of 0.53. The F (3,140) value at 0.05 significance level is 2.68 and is much higher. Maturation and history were thus considered to have no effect on students science concept attainment scores.

TABLE 8 — COST: ORTHOGONAL COMPARISON BETWEEN EXPERIMENTAL GROUPS AND CONTROL GROUPS — POST-TEST SCORES

Sample	Size	Mean	Std. Dev
Experimental groups	72	20.93	3.53
Control groups	108	19.28	3.78

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F-Ratio	p
Among samples	1	118.00	118.00	8.71	0.01
Within replications	178	2412.32	13.55		
Total	179	2530.32			

TABLE 9 — COST: ONE-WAY ANOVA OF GROUPS 1, 2, 5 PRE-TEST SCORES AND GROUP 4 POST-TEST SCORES

Sample	Size	Mean	Std Dev
Group 1 pre-test	36	17.83	3.88
Group 2 pre-test	36	18.75	3.63
Group 3 pre-test	36	18.31	4.03
Group 4 post-test	36	18.89	4.11

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F-Ratio	p
Among samples	3	24.61	8.20	0.53	N.S.
Within replications	140	2148.95	15.35		
Total	143	2173.55			

SCIENCE ACHIEVEMENT SCORES

It was earlier demonstrated that from the mid-year science examination marks, students in all five experimental units were of comparable ability in science achievement. The final term science examination results, however, indicated otherwise.

Table 10 displays the distribution of marks attained by each unit. The distribution showed that a noticeably larger number of students in experimental Groups 1 and 3 compared to the remaining control groups, scored above 60%.

The means and standard deviations of the scores on selected questions, as well as the over-

TABLE 10 — DISTRIBUTION OF MARKS IN FINAL TERM SCIENCE EXAMINATION

Grade Category	Group 1	Group 2	Group 3	Group 4	Group 5
20–24				1	
25–29				2	
30–34		1	1	1	
35–39	1	1	1	1	
40–44	1	3	1	3	
45–49	3	5	2	7	2
50–54	5	5	4	2	14
55–59	3	8	5	4	6
60–64	9	8	11	5	3
65–69	8	1	6	4	7
70–74	4	3	1	1	1
75–79		1	1	2	1
80–84	2		3	3	
Total	36	36	36	36	36
% Scoring > 60%	63.9	36.1	61.1	41.7	38.9

TABLE 11 — DESCRIPTIVE STATISTICS OF SUBJECTS' SCORES IN FINAL TERM SCIENCE EXAMINATION (ALL & SELECTED ITEMS)

Variable	Mean	Std Dev	Variance	Std Error of Mean	Coeff of Variation
Gp 1, all items	61.36	9.97	99.38	1.66	16.25
Gp 1, selected	26.14	4.07	16.58	0.68	15.58
Gp 2, all items	56.39	10.21	104.24	1.701	18.11
Gp 2, selected	23.06	4.43	19.65	0.74	19.23
Gp 3, all items	60.58	11.28	127.28	1.88	18.62
Gp 3, selected	26.47	3.98	15.86	0.66	15.04
Gp 4, all items	55.50	15.75	247.91	2.62	28.37
Gp 4, selected	23.94	6.50	42.28	1.08	27.16
Gp 5, all items	58.92	8.33	69.34	1.39	14.13
Gp 5, selected	22.75	4.25	18.08	0.71	18.69

all scores, of the final term science examination, are found in Table 11.

Table 12 shows another analysis which considered only those examination questions related to activities at the Singapore Science Centre. An orthogonal comparison was carried out on the mean scores between the two experimental and three control groups. The difference of means indicated strong significance. The obtained F-ratio (1,178) of 18.10 was at the 0.01 level of significance. Students in Groups 1 and 3 demonstrated a superior performance over their peers in the control groups.

It was even more encouraging to observe that in a similar analysis, this time using only the examinaton's overall score, the difference of mean scores between the two experimental and three control groups combined gave an F-ratio of 5.47, significant at the 0.05 level. This is shown in Table 13.

Since the mean science achievement scores favoured Groups 1 and 3, the science enrich-

TABLE 12 — ORTHOGONAL COMPARISON BETWEEN EXPERIMENTAL GROUPS AND CONTROL GROUPS (SCORES OF SELECTED QUESTIONS IN 1984 FINAL TERM SCIENCE EXAMINATION)

Sample	Size	Mean	Std Dev
Experimental groups	72	26.31	4.00
Control groups	108	23.25	5.14

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F-Ratio	p
Among samples	1	403.33	403.33	18.10	0.01
Within replications	178	3965.53	22.28		
Total	179	4368.86			

TABLE 13 — ORTHOGONAL COMPARISON BETWEEN EXPERIMENTAL GROUPS AND CONTROL GROUPS (SCORES OF 1984 FINAL TERM SCIENCE EXAMINATION)

Sample	Size	Mean	Std Dev
Experimental groups	72	60.97	10.58
Control groups	108	56.94	11.83

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F-Ratio	p
Among samples	1	704.06	704.06	5.47	0.05
Within replications	178	22922.50	128.78		
Total	179	23626.60			

ment activity effect was thus substantiated. The results in Tables 12 and 13 indicated that students in these two groups achieved high marks both on items relevant to their enrichment experiences and in the overall science examination paper. This gave strong support for the hypothesis that pupils who receive structured enrichment activities would achieve better scores in the school science examination compared to those who do not receive such activities.

TABLE 14 — CORRELATIONS BETWEEN SCIENCE CONCEPT ATTAINMENT AND SCIENCE ACHIEVEMENT

Correlation	df	Obtained r	^{r}Critical $\alpha = 0.01$	p
COST (POST) × Final (SEL)	178	0.51	0.19	0.01
COST (POST) × Final (TOT)	178	0.52	0.19	0.01

Note: (SEL) = Selected scores
(TOT) = Total scores

CORRELATIONS BETWEEN SCORES ON COST AND FINAL TERM SCIENCE EXAMINATION

There is evidence in the science education literature that a relationship exists between the factors of concept attainment and achievement. Hence, correlations were performed on scores obtained to find out whether the relationship was significant in this study.

Positive and significant correlations were evident between science concept attainment and science achievement (Table 14). The results indicated that concept attainment was strongly related to science achievement.

Discussion

Statistical results of this study supported the hypotheses proposed earlier.

SCIENCE CONCEPT ATTAINMENT

Johnson and Oreilly (1964), Chang (1974), Linn (1980), Wright (1980), and Abdullah and Lowell (1981), postulated that provision of relevant experiences would improve comprehension and application of science concepts, and help students achieve good results. Chang's (1974) finding was reinforced by statistical evidence from the present study.

Results of statistical analyses (t-tests and F-ratios) showed that both experimental Groups 1 and 3 fared well and outperformed their control peers in COST. Their written responses also indicated that the enrichment sessions gave them new experiences and knowledge both in scope and depth. This helped immensely in understanding what the teacher was trying to convey to them in class.

Seventy-three percent of the students in the three control groups admitted having special difficulty in understanding physics topics, despite the teacher's repeated explanations. This verified what King (1961), Busch (1966), Chang (1974), and Wright (1980) have noted on the effectiveness of providing meaningful concrete experiences to enhance learning. The relatively lower level in concept attainment of the control group students was also consistent with the findings of Disinger and Mayer (1974) who emphasised the importance of what the teacher can do to improve learning.

Those control students, who believed that being in the science stream would give them an advantage in their further studies, strove to do well just to be selected for the course. Chang (1974) recorded similar responses from her control students who scored lowly on interest scores but fared well in the science concept test.

SCIENCE ACHIEVEMENT

The school science examination results also indicated that the enrichment activities had favourable effects on students' achievement.

As demonstrated in the mark distribution table and analyses using orthogonal comparison of group means, the experimental groups did far better than the control groups. Even when the examination's overall score, which had no bias on the experiment, was taken as a basis for comparison, the results favoured Groups 1 and 3.

This reaffirmed Chang's (1974) findings that supplementary science programmes had a positive influence on learning and contributed to an improvement in achievement.

The excursions for the Hawthorne control group were however not as effective in bringing about better achievement. They were unrelated to school science, and seemed unable to improve the students' understanding of science topics and upgrade their examination results.

Past research (Kuhnen, 1960; Bennett, 1965; Babikian, 1971; Chang, 1974; Kolodity, 1977; Linn, 1980) and present findings stress the need, particularly in practical subjects like science, for supplementing school lessons with meaningful activities because these activities have been shown to affect achievement favourably. Currently in the Singapore context such experiences should aptly complement the activity-centred LSS curriculum.

RELATIONSHIP BETWEEN SCIENCE CONCEPT ATTAINMENT AND ACHIEVEMENT

A strong relationship was found between science concept attainment and science achievement. This study strongly supported the idea of encouraging participation in science enrichment activities which could improve understanding and achievement.

Conclusion

The study demonstrated that there were opportunities to learn out of school as well as in it. It explored the effects of out-of-school science enrichment activities in the wake of a growing recognition of the value and complementary role played by this aspect of learning to formal schooling.

There is presently a firm movement away from traditional methods relying almost entirely on the teacher, and a cramped syllabus of work aimed soley at achieving good examination results. As a practical subject, science is best taught by exposing students to relevant experiences through projects, film and slide shows, field studies, quizzes and excursions.

Research evidence has led to the hypothesis that enrichment experiences have favourable effects on the acquisition of science concepts and achievement. This was verified in the present research and the results were reassuring. They implied that an activity-centred inquiry-based science course, combined with meaningful co-curricular activities, improve understanding of concepts, principles, and the social aspects of science. This would mean that science teachers should design activities that challenge students, and employ a variety of uniquely suitable instructional practices to arouse interest, enhance learning, and make science in school palatable to students.

Schools are ideal places for sequential learning. However, school science programmes usually lack the ability to motivate students and arouse their curiosity. Enrichment activities allow for this through a cross-fertilisation between formal and non-formal science education.

Taking students out of school is not, of course, new. Under the right circumstances any educational trip for a class can be an enriching and enjoyable experience. If poorly planned, it can turn out to be a sheer waste of time, and students may be put off by these trips for good. Careful and intentional planning, adequate supervision, specific visitational goals and student-centred activities, would ensure that teachers and students reap the benefits of these experiences.

The findings of this study must be limited to its application of students in an all-girls' school. However, if they are valid indicators of pupils' feelings for science, then schools might well review their science curriculum and instructional methods. If current science programmes are to meet the demands of our rapidly changing society, then positive and constant rethinking of the goals of science teaching and learning must inevitably continue.

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