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A Comparison of the Effectiveness of Inquiry-Oriented Teaching With Traditional Teaching in the Maldives

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A COMPARISON OF THE EFFECTIVENESS OF INQUIRY-ORIENTED TEACHING WITH TRADITIONAL TEACHING IN THE MALDIVES

by

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USE OF THESIS

Abstract

This thesis compares the effectiveness of an activity-based, inquiry oriented approach using simple, inexpensive, locally available equipment with a traditional approach, in enhancing student achievement and positive attitudes towards science in the Maldives.

The sample consisted of 79 boys range from 13 to 16 years of age from two year eight classes in a private lower secondary high school.

A quasi experimental non equivalent control group research design was adopted for the study. The control group was taught the currently existent curriculum for two weeks in the traditional manner while the treatment group was taught using a curriculum package developed for this study. The students were pre, post and delayed posttested to evaluate changes in student achievement and attitudes.

The inquiry group was found to have a higher achievement retention level while no significant differences were observed between the attitudes of the two groups at the p=0.05 level. The study suggests that the inquiry-oriented approach is effective in promoting student achievement and postive attitudes in the Maldivian context.

Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signature...[redacted]................

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Chapter 1

Introduction

Background

Maldives is an island nation striving to provide better educational services for it's people. Of an approximate population of two hundred thousand people, about fifty five thousand live in the capital, Male' (MPE ,1990). Most of the schools, hospitals and other such facilities found in Male' tend to be better resourced than those found in the neighbouring islands. The rest are distributed across the other 202 inhabited islands which make up the twenty atolls of the archipelago. The number of inhabited islands in each atoll varies from 1 in Fuamulah to 17 in South Thiladhummathi.

The distributed population of secondary aged children in the different atolls were projected for 1995 and 2000 by Ismail (1993, p. 12) as shown in Table 1. A number of these children migrate to the capital to attend secondary school. Therefore the major proportion of the secondary aged population of the Maldives reside in Male'. The estimated increase of the secondary aged populations in these atolls emphasises the need for secondary education opportunities to be available for this growing populace. Furthermore, Ismail (1993) estimates that secondary aged populations of at least 150 of the 203 islands would be less than 150, even by 2000. Hence it can be seen that planning for economical resource allocation for secondary education in the Maldives is a necessity.

Currently there are only 3 government secondary schools in the Maldives. Of these, only one (established in 1992) is situated outside the capital. As a result, there is a steady influx of secondary aged children into Male'. In fact 51% of the population

migrating to Male' is accounted for by secondary aged children. Ismail (1993, p. 15) suggests that the major factor which draws this group of people to Male is the opportunity for education.

Table 1

Projection of secondary aged children for 1995 and 200 by atoll (Ismail, 1993, p. 12)

Atoll	1995	2000
North Thilandhunmathi	1009	1450
South Thiladhunmathi	1071	1563
North Miladhunmadulu	790	994
South Miladhunmadulu	699	987
North Malhosmadulu	940	1330
South Malhosmadulu	698	913
Faadhippolhu	593	773
Malé Atholhu	518	621
North Ari Atholhu	354	495
South Ari Atholhu	426	691
Felidhu Atholhu	116	190
Mulakatholhu	364	438
North Nilandhe Atholhu	231	387
South Nilandhe Atholhu	356	514
Kolhumadulu	734	981
Hadhdhunmathi	817	1099
North Huvadhu Atholhu	684	881
South Huvadhu Atholhu	996	1278
Fuamulah	599	819
Addu Atholhu	1266	1867

Source : MPE (1992)

Due to limited enrolments in the government schools, a few private schools have developed to cope with this influx. However these private schools operate on limited funds and hence cannot provide the same facilities as those provided by the government schools. Nevertheless it has to be recognised that the private schools provide secondary education opportunities for the majority of the incoming student population. It is

envisaged that the establishment of the newly planned government lower secondary school in the north in 1997 would increase secondary education opportunities for students in the northern atolls. It is evident therefore, that secondary education in the Maldives is supported by the combined efforts of the government and the community.

As a response to the over population of the capital, the Maldivian government is attempting to provide better educational, health and other essential facilities on other islands in an effort to disperse the population of Male'. Such a venture demands the utilisation of a considerable proportion of its limited available resources. Hence it is envisaged that the opportunity for more progressive developments in secondary science education will be limited. Moreover, Ismail (1993, p. 13) estimates a 23% increase in the student population of the Maldives by 2000. Such an increase would require a larger proportion of the already limited available resources to be spent for effective secondary science education. The need for cost effective, satisfactory secondary education is evident. The curriculum package developed for this study utilises a cost effective, activity-based, inquiry-oriented approach for teaching concepts related to Balance.

Significance of the study

In Male', at present, secondary science teaching is didactic and content-based. It is felt that the external assessment driven nature of the secondary science curriculum (due to the London Certificates of Education examinations at the end of years ten and twelve) and the reluctance of teachers to risk the output of consistent achievement levels are possibly the main reasons why the teaching approach has not been varied.

The science curriculum implemented in the secondary schools is based on the British curriculum. This curriculum assumes the availability of modern technical equipment

and the suitability of such a curriculum to the Maldives. The utilisation of the British curriculum in the private schools as well as the new government schools would require the use of expensive, commercially prepared equipment that would have to be imported at a very high cost. The use of simple, locally available equipment in the proposed study provides an alternative to the spending of limited available resources on expensive, technical equipment as well as providing more familiar equipment and suitable activities for the Maldivian student.

Statement of the problem

The current views of learning (concurrent with inquiry-oriented learning) perceive the learner as an active participant (Saunders, 1992; Anderson cited in Woolfolk, 1993; Biggs and Moore, 1993). Inquiry-oriented, activity-based teaching has been found to enhance student achievement and positive attitudes towards science (Hall and McCurdy, 1990; Rubin and Tamir, 1988; Shymansky, Hedges and Woodworth, 1990; Kyle Bonnsetter and Gadsden, 1983; Germann, 1989; Fowler and Mulapo, 1987; and Shepardson and Pizzini, 1993). Nevertheless as a result of limited available resources, secondary science education in the Maldives has remained didactic. The comparative effectiveness of these two approaches needs to be validated in the Maldivian context before an inquiry-oriented approach can be implemented.

This study aims to compare an activity-based, inquiry-oriented approach using simple, inexpensive, locally available instructional materials with a traditional teaching approach with reference to the achievement in the understanding of the concepts and attitudes related to balance. The role of inquiry learning in improving scientific process skills has been emphasised by Roth and Roychoudhury (1993). However due to the length of the module produced, the effect of inquiry learning on process skills will not be

investigated in this study. Furthermore the importance of activities and inquiry in science teaching, and building of attitudes is hoped to be emphasised through the study. Hence the study aims to obtain information on which one could make an informed decision about the relative suitability of the two teaching approaches to the Maldivian context.

Research Questions

Question 1.

Does activity-based, inquiry oriented teaching using simple, inexpensive, locally available equipment lead to a better student understanding of the nature of balance than a traditional method?

Question 2.

How does activity-based, inquiry oriented teaching and the use of simple, inexpensive, locally available equipment affect student attitudes towards science compared to a traditional approach?

Definition of terms:

The major terms and abbreviations which are used in this study are defined as follows:

1. Achievement - this will refer to the attained level of performance (Longman Dictionary, 1991).

2. Atoll - a group of islands.

3. Learning - "a process through which experience causes a permanent change in knowledge or behaviour" (Woolfolk, 1993, p. 196).

4. Inquiry - "the process of finding out" (Collette and Chiappettta, 1989, p. 76) through "defining and investigating problems, formulating hypotheses, designing experiments, gathering data, and drawing conclusions based on the data" (Trowbridge and Bybee, 1986, p. 183).

5. The inquiry approach - refers to a student centred, activity-based, teaching approach where the student is actively involved in the construction of meaning.

6. The traditional approach - refers to a teacher-centred, didactic fact oriented approach where the students' role is that of a passive receptor

Summary

In the Maldives a traditional teaching approach is used in secondary science education. An inquiry-oriented, activity-based approach to teaching would be more analogous to current views of learning. However the effectiveness of such an approach has not been investigated in the Maldivian context.

The lack of resources and teacher support material are significant factors which would effect the successful implementation of such an approach. The curriculum package developed for this study utilises inexpensive, simple and locally available materials and

highlights the need for teacher support material. This study proposes to provide information about the effectiveness of an inquiry-oriented, activity-based approach at a low cost.

Chapter 2

Literature Review

Teachers employ a varied selection of teaching approaches and strategies. Of these, the most commonly used method in Maldivian schools is one which views the teacher as the source of knowledge and the controller of learning and the students as passive learners who receive information. This method will be referred to as the traditional approach throughout this study.

Differences between inquiry and traditional approaches to teaching

The process of inquiry is defined by Collete and Chiappetta (1989, p. 76) as the process of finding out and by Bybee and Trowbridge (1986, p. 183) as including the processes of defining and investigating problems, formulating hypotheses, designing experiments, gathering data and drawing conclusions on the basis of that data.

The inquiry approach to teaching is a student-centred, activity-based approach where the role of the student is that of an active learner, with the teacher acting as a facilitator. This approach requires the student to be the seeker of knowledge, using the process of inquiry to manipulate the resources available to him/her in order to access, gain and verify new information (Woolfolk, 1993, p. 455). Therefore, the activity-based nature of the inquiry approach is established through it's very nature.

Inquiry-oriented learning inspires the students to construct their own meanings from what is learned. It is therefore easier for students to costruct meanings by recalling their own efforts than through explanations by the teacher.

On the other hand, the traditional approach is very teacher-centred, didactic, fact oriented and is usually implemented through 'chalk and talk'. It is also very similar to the lecture method of teaching described by Woolfolk (1993, p. 448) where students have little opportunity to ask questions and become actively involved in the learning process. These differences between inquiry and non-inquiry methods (of which the traditional approach is one) are summarised in Table 2.

Teachers often tend to provide all the necessary information to the students, based on a mistaken assumption that students assimilate all the information provided to them. This 'covering' tendency is characteristic of traditional teaching.

The levels of inquiry

Classroom activities can involve varied levels of inquiry. Levels of inquiry can be explained as the amount of autonomy the student has, over the inquiry. The difference in these levels are determined by who (the student or the teacher) decides on:

(i) what to investigate,

(ii) how to investigate,

(iii) what materials to use, and

(iv) who evaluates the investigation (Figure 1)

Verification activities involve the lowest level of inquiry. Verification activities are those where the teacher decides on what the students are going to investigate, how they are going to do it and what materials they are going to use. Furthermore the teacher informs the students what they will observe through their investigation. Hence students are only concerned with getting the 'right' answer. It is normal practice in such lessons for students to ignore any supposedly 'incorrect' observations. Consequently they tend not to contemplate

why the right answer was not obtained; thereby losing critical information, which could give them a better understanding of the concepts involved.

Table 2

Differences between inquiry and non-inquiry (Trowbridge and Bybee, 1986, p. 187)

NON-INQUIRY	INQUIRY
Teacher covers more but less is retained	Teacher covers less but more is retained
Teacher orientation- students viewed as reservoir of knowledge, subject centred, teachers have covering compulsion.	Teacher orientation- holistic view of learner, student centred, teachers are more interested in cognitive and creative growth.

In contrast, a free inquiry lesson is one where the student decides what to study, how to do it, and the materials to be employed for the investigation. The observations made are deemed to be 'correct' and students hypothesise about the findings. All information obtained through the investigation is used.

Although the advantages of free inquiry in promoting higher levels of learning has been highlighted by Bybee and Trowbridge (1986, p. 183) and Collette and Chiappetta (1989, p. 79), the problems involved in implementing such an approach need to be considered. Such an undertaking would require a lot of time; not to mention the accountability problems associated with it. Furthermore students may get distracted by unimportant fragments of information obtained from such activities. Hence a more suited approach **may** be the guided inquiry approach.

In a guided inquiry lesson, the teacher generally decides what is to be investigated and how. The materials to be used are also generally chosen by the teacher. However, the results of the investigation are evaluated by the student through the investigation. In this approach the teacher arranges the learning experiences to facilitate students' learning so that they do not get side tracked by irrelevant information and therefore facilitates successful learning.

The aim of teaching is to generate successful learning. The effectiveness of any one approach can only be discussed in terms of the successful learning it yields and to do this, learning has to be defined.

Verification<--------------------------------->Free inquiry

Level	0	1	2a	2b	3
Define investigation	T	T	T	T	S
Choose method	T	T	T	S	S
Choose materials	T	T	S	S	S
Evaluate	T	S	S	S	S

T - teacher
S - student

Figure 1. Levels of Inquiry (adapted from Hegarty , 1978, p. 47)

What is learning?

Learning is defined by Woolfolk (1993, p. 196) as a:

"...process through which experience causes permanent change in knowledge or behaviour".

Many theorists have argued different views of learning. Of these the two main viewpoints are the behavioural and cognitive viewpoints. The behavioural perspective

emphasises that it is the behaviours themselves that are learnt, while the cognitive favours the acquisition of new information which makes changes in behaviour possible (Shuell, 1986). As this study is concerned with the relative effectiveness of two teaching approaches in producing learning of new knowledge associated with the concepts of balance, the cognitive perspective is assumed.

According to the cognitivists, people are active processors of information, initiating experiences that lead to learning, seeking out information to solve problems and reorganising what they already know, in their efforts to understand the world (Woolfolk, 1993, p. 89). Woolfolk proposes the information processing model as one of the most influential learning models associated with the cognitive view of learning. In this model, the learner is perceived as a selective processor of all information that is perceived through the five senses. The features of this model are summarised in Figure 2

The constructivistic view of learning, which grew from the cognitive base of learning, is described by Saunders (1992, p. 136)as follows:

> " It is the notion that learners respond to their sensory experiences by building or constructing in their minds, schemas or cognitive structures which constitute the meaning and understanding of their world".

Explaining further, Anderson (1989a), quoted in Woolfolk (1993, p. 485) states that it is a:

> "...constructive process in which knowledge structures are continually changed to assimilate and accommodate new information. The learner is more than a passive vessel for knowledge structures; rather, the learner is like a traffic cop who sometimes lets the traffic of information flow automatically and sometimes steps in actively to direct the process of sense making".

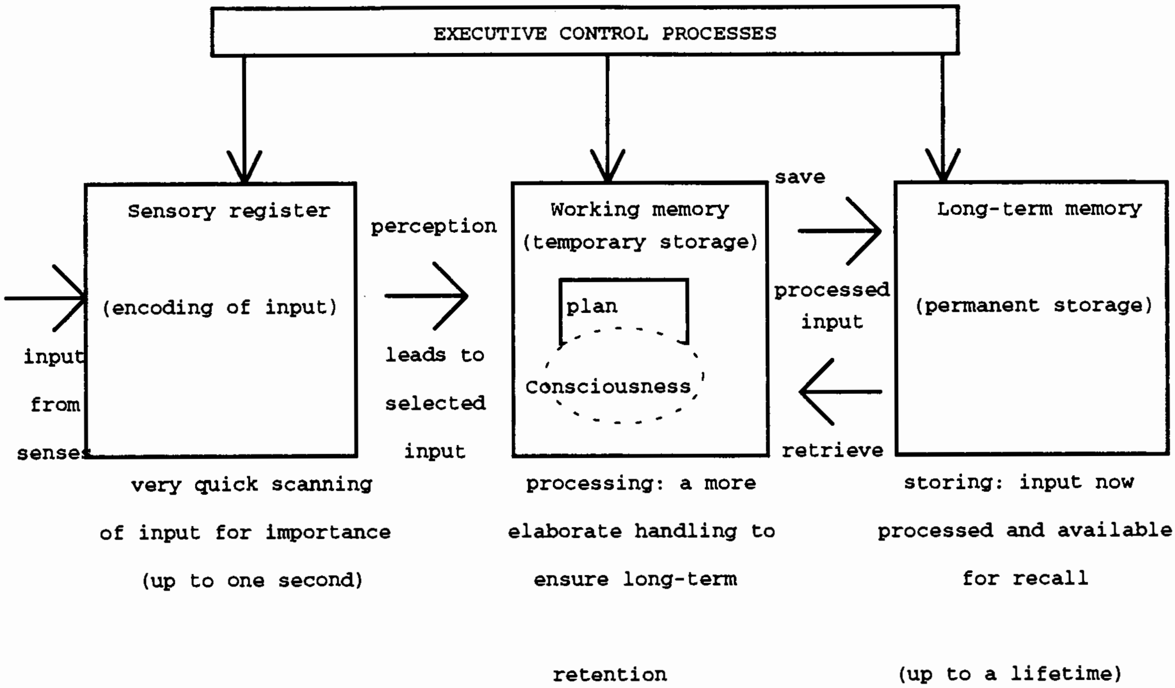

Figure 2. The information processing model adapted from Woolfolk (1993, p. 243) and Biggs and Moore (1993, p. 207)

If the constructivist view of learning is true, as assumed, then teachers cannot build the cognitive structures for the students but can only provide experiences that can promote the construction of the desired schemas, structures or learning.

How can inquiry oriented practical work foster learning in science?

Practical work provides students with a greater variety of sensory stimuli than the traditional approach. According to Saunders (1992) it is the sensory stimuli experienced by the learner that helps build cognitive structures in his/her mind. Hence the greater number of senses stimulated through activity-based work increases the chance of previous memory structures to be triggered. Manipulation of the apparatus used in activity-based lessons also

increases learning as it involves reformulation of the ideas discussed or instructions given, to the deed (Watts and Ebbut ,1988).

Inquiry learning requires the retrieval of information stored in long-term memory in order to make sense of the new information perceived. This association of old information with the new ensures the movement of new information to long-term memory (Woolfolk, 1993, p. 249).

The level of learning produced can be affected by inquiry-oriented learning. According to Bloom's levels of cognitive learning (Barry and King, 1993, p. 52), higher cognitive levels of learning should result when inquiry-oriented methods of teaching are used. This is due to the fact that the inquiry process favours the use of application, analysis, synthesis and evaluation as well as the acquisition of knowledge and understanding.

The importance of the above mentioned methods in science teaching is emphasised by the definition of science. Science is referred to by Collete and Chiappetta (1989) as:

> "...a way of investigating, a way of thinking and as a body of established knowledge."

These characteristics of science are congruent with those of inquiry learning (Figure 3). The relationship between active learning, science and inquiry all include the process of finding out.

<u>Other factors that influence the selection of a teaching approach</u>

Selection of any teaching strategy or approach depends on the factors outlined by Dawson (1991, p. 59) in Figure 4. The choice may be constrained by school and teacher characteristics, the nature of learners and the aims of the school.

In the Maldivian context, laboratory space and equipment are extremely limited. Most teachers are used to a traditional method of teaching, which is viewed by both the students and the community as 'real' teaching. The students, moulded through primary school, become passive acceptors by the time they reach secondary school. Class sizes are large, with approximately thirty students accommodated in cramped rooms (especially in private schools).

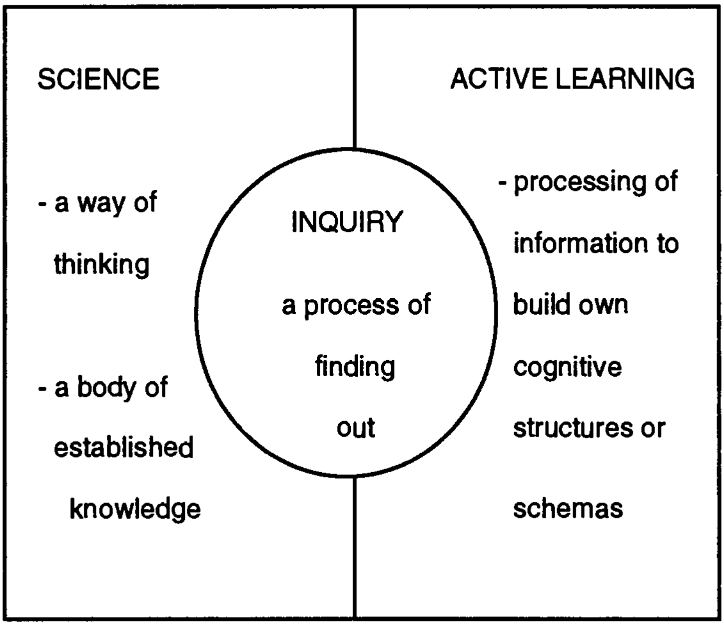

Figure 3. The link between science, inquiry and active learning

Nevertheless these restrictions can be overcome through innovative thinking. The problem of expensive laboratory equipment can be solved by using simple, inexpensive and locally available materials as often as possible. Rearrangement of classrooms can create bench space for activity-based lessons. Teacher inservicing and the gradual adoption of inquiry-oriented, activity-based curricula would reduce chances of the rejection of this approach by students, teachers and the community.

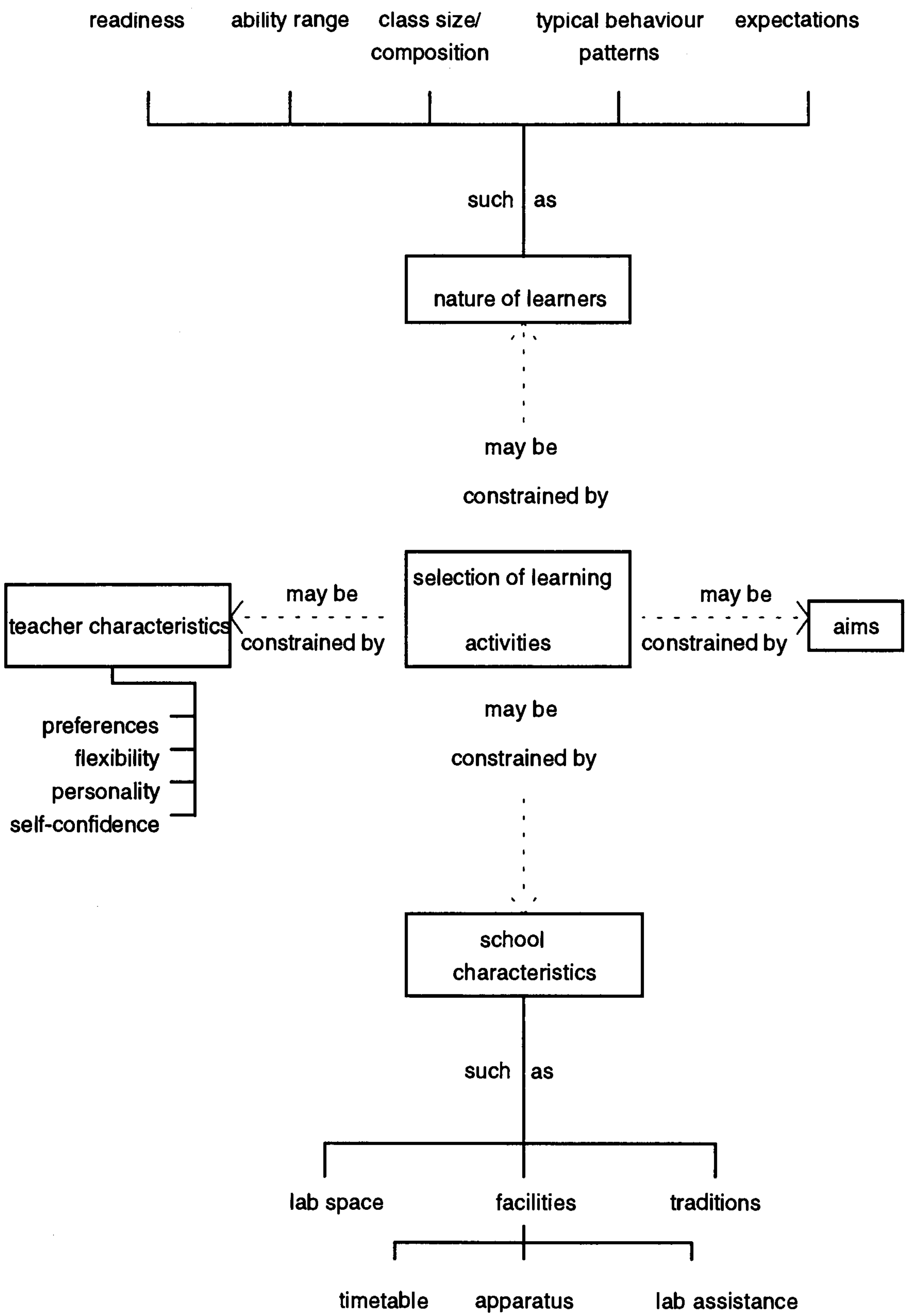

Figure 4. Other factors affecting the selection of a teaching approach (Dawson, 1991, p. 59)

Methods of implementing the approach

Activities can be incorporated into currently practiced traditional teaching methods as introductions to the content, investigative activities through which the content is presented or as a verification of information.

Inquiry can be practised through questioning by including science process questions and by using Suchman's Yes/No technique (Collette and Chiappetta, 1989, p. 80). Discrepant events used to spark inquiry in demonstrations are particularly useful in correcting misconceptions. Problem-solving, and inductive activities enhance inquiry in science. Research-based reading, surveying and other methods of information collection can also promote inquiry.

Carrying out investigations, especially student generated ones represents inquiry in the truest sense of the word, especially because of student commitment and the meaning it holds for him/her. Some of the above mentioned methods (such as student generated investigations) belong to the free inquiry end of the continuum (Figure 1), while others tend to be of the guided inquiry type (such as inductive activities), where the teacher plans the learning environment. Hence it is important to note that each of the methods mentioned above emphasises different levels of inquiry due to it's particular characteristics. The variety of ways in which the approach can be implemented allows each individual teacher to choose the method most suited to him/her in order to be able to perform effectively.

The effect of inquiry teaching

Schibeci and Riley (1986) cited in Shymansky (1988), identified a strong relationship between perception of instruction, student attitude and their achievement. They found that

the manner in which the students perceived the instruction affected their attitudes, which in turn determined their levels of achievement.

Achievement.

Research has been carried out extensively on inquiry teaching in the past few decades. Most of the research available on inquiry in science education has been done with specific reference to laboratory work.

Hall and McCurdy (1990) compared inquiry-oriented laboratory work with traditional laboratory work in relation to content achievement. They found content achievement to be higher for students who partook of the inquiry laboratories. A similar study carried out by Rubin and Tamir (1988) produced analogous results. A meta-analysis of the effects of inquiry-based curricula of the 1960's revealed that the achievement increased at the junior and senior high school levels as a result of the new curricula (Shymansky, Hedges and Woodworth, 1990). The study also compared the achievement levels of students from urban, suburban and rural schools where these types of curricula were used. Urban schools benefited most from the curricula, displaying the highest achievement levels with the suburban schools showing a lower level of achievement. Achievement in rural schools remained unaffected.

The validity of such conclusions, however, are open to scrutiny. Tamir (1977) and Kyle (1977) cited in Hodson (1985, p. 46), state that the difference in any curriculum plan and the teaching that takes place inside the classroom can be quite significant. Therefore the higher cognitive levels of learning can be a result of many other determinants.

The level of inquiry used could be a major component that affects the level of learning. Yet there does not seem to be any research substantiating this hypothesis. Nevertheless many, including Bybee and Trowbridge (1986), believe that free inquiry (where defining the area of investigation, the choice of method of investigation and the evaluation of the data are carried out by the student) leads to higher levels of cognition than structured inquiry.

Some studies have suggested that inquiry teaching might not be as beneficial in terms of producing achievement as other approaches. Fowler and Mulapo (1987) found that the traditional approach was more effective in increasing student achievement than the inquiry approach. A meta-analysis of the effects of various science teaching strategies on achievement carried out by Wise and Okey revealed that inquiry-discovery strategies did not produce a content achievement as high as that for focussing, questioning and manipulative strategies.

However there is reason to question Wise and Okey's (1983) findings. The meta-analysis was based on comparing effect sizes in different studies. Preece (1983, p. 183) describes Effect size, a key statistic, as the difference between experimental group and control group means, on the outcome measures, divided by the standard deviation of the control group or the pooled within group standard deviation (if this is the only information available). He maintains that pretest-posttest-covariance-adjusted studies would have inflated effect sizes in comparison with posttest only studies. Lott (1983) accounted for this variance in comparing the effect of inductive and deductive activities and found that there was no difference in achievement for students in both groups.

Possible reasons for the above mentioned results can be summarised by Woolnough and Allsop's (1985) views on the effectiveness of inquiry in promoting achievement as cited in Kahn (1990, p. 130):

" First, the 'restrictive exercises' of inquiry science are unrealistic. Second, there is the weakness of practical work as a means to acquire theoretical understanding."

On the other hand, Mayer (1985) discusses the use of laboratory activities for verification purposes in Kahn (1990, p. 130) :

"When the laboratory is used simply to confirm data to which the pupil has already been exposed, the laboratory becomes only an expensive and time consuming way of checking up on the text book."

Hence, a more realistic, effective approach to incorporating inquiry into science lessons would be to use a structured or guided inquiry approach. Fuller (1987, p. 284) confirmed this when he found that high content achievement was obtained by implementing active teaching and learning methods. The active learning methods referred to are comparable to Saunders' (1992, p. 136) definition of the constructivistic view of learning. Doty (1985) obtained similar results in a study comparing inquiry and traditional methods of teaching.

Student attitude.

Kyle, Bonnsetter and Gadsden's study (1983) indicates that students in inquiry-based classrooms have more positive attitudes towards science than those in the traditional classrooms. Germann (1989), Fowler and Mulapo (1987) and Shepardson and Pizzini (1993) supported these results through their studies.

Shymansky, Hedges and Woodworth (1990) compared student perceptions of inquiry-based curricula at different types of schools at different levels. At the senior high school level, students had positive perceptions of the curricula. However at the junior high school level there was no significant positive impact on students' perceptions of science. In like manner, Hall and McCurdy (1990) found no statistically significant differences between the attitudes of students exposed to inquiry and traditional approaches.

Student perceptions of science were significantly positive at rural schools as a result of implementing inquiry-based curricula. Suburban schools displayed a lower level of positive perceptions while in urban schools perceptions remained unaffected (Shymansky, Hedges and Woodworth, 1990). Details of the levels of inquiry used in the actual implementation of the curricula were not provided suggesting that possible differences in the levels of inquiry used in the implementation at different schools could have been a variable (Tamir and Kyle (cited in Hodson, 1985).

The effect of activity-based learning

Achievement.

Fowler and Mulapo (1987) and Mensch and Rubba (1991) reported high achievement levels with the use of hands-on, activity-based learning techniques. Similar effects were observed in India, Thailand and Iran, but not in Latin America (Fuller, 1987). Ohanenye (1986) found that such approaches implemented in a Nigerian context effected students' achievement levels positively, suggesting that achievement can be enhanced using activity-based approaches in Third world countries.

Research on the effectiveness of such approaches appears to be limited in Third World countries. Due to the lack of available literature on this subject this suggestion cannot be validated.

Student attitudes.

The effectiveness of hands-on, activity-based learning techniques in producing positive attitudes towards science were established by Fowler and Mulapo (1987) and Mensch and Rubba (1991). Ohanenye (1986) found that students perceived this approach to teaching more positively than the traditional method in Nigeria. However Abunejmeh (1985) did not detect any significant increases in student attitude as a result of teaching Chemistry through an activitiy-based approach.

The effect of using instructional materials on achievement

A meta-analysis of studies carried out in schools in third world countries showed that instructional materials exerted significant influence on achievement (Fuller, 1987). Most of the instructional materials used in the studies analysed by Fuller (1987) were texts, reading materials, physical facilities and instructional media. These materials were found to increase achievement in Third World countries. Although this study did not focus on the use of materials in hands-on work, it provides an indication of how materials used in such an approach could effect achievement.

Summary of the chapter

Most of the literature supports the positive effect of inquiry-oriented, activity-based, materials centred teaching on student achievement and attitudes. The effectiveness of such

an approach in promoting higher levels of cognition and in extending students' levels of thinking, is also implied.

Chapter 3

Methodology

A quasi experimental approach was used to determine the relative effectiveness of the teaching approach. The nature of this design and other factors pertaining to the methodology are outlined in the following sections of this chapter.

Subjects

All the secondary schools in the Maldives operate on a single sex basis. Hence the effectiveness of this teaching approach can only be determined in this context.

The sample consisted of two Grade Eight classes (of approximately 40 students each) from a private secondary boys' school. The sample included boys ranging from thirteen to sixteen years of age. It is normal practice for a class in a private secondary school to contain students of a relatively broad age range.

The reasons for electing this particular school include their willingness to cooperate and its representative nature of almost all other secondary private schools. Hence it is acknowledged that the findings can only be generalised to similar schools.

The students were not randomly assigned to the two groups due to administrative difficulties within the school. This difficulty can be explained by the usual enrolment practises within the school. The majority of the student population of private schools tend to be students from islands other than Male'. Lack of accommodation, sponsorship and other personal factors determine students' sojourn in the school. It is therefore typical for students

to enrol in or withdraw from the school in the middle of the academic year. Hence students are ability grouped to overcome the difficulties associated with the large differences in their academic abilities. This grouping is based on the total of their academic scores from the previous year, or the score obtained on an entrance test. The two groups involved in this research were the 'most able' and the 'second-most able' grade eight classes.

Design

A quasi experimental, non equivalent control group design was used as shown in Table 3. Gay (1992, p. 327) proposes this approach to be the most suited for a study of this nature due to the comparative nature of the study of two presumably unequal existing groups. The treatment (the activity-based, inquiry-oriented approach) was assigned to the 'second-most able' group while the 'most able' group was assigned to the control (the traditional approach). These groups will be called the inquiry and traditional groups henceforth. The inquiry group was taught using a specially developed activity-based, inquiry-oriented curriculum package (Appendix A).

The significance of the assignation is in its strengthening of the findings. If the understanding of the students of the inquiry group (who are supposed to be 'less able' than the traditional group) of the curriculum material presented, positively affects their achievement, the applicability of the developed curriculum material with extension materials, for more able Grade Eight student groups can be established.

The test, used as the pre, post and delayed posttest, employed to examine students' understanding of the concepts, was developed for this particular project. An attitude questionnaire was developed for the same purpose.

Observations of the two interventions by a third party, verified the authenticity of the two different teaching approaches through the use of a checklist (Appendix B) that was developed for this purpose. The aim of this exercise was to provide an unbiased view of the actual teaching that took place. Observations of the independent observer are appended in Appendix B.

Table 3

The design of the study

TIME	CONTROL GROUP (Traditional)	TREATMENT GROUP (activity-based, inquiry-oriented)
week 1- day 1	pretest - achievement - attitude	pretest - achievement - attitude
weeks 1 and 2 (OBSERVATION by independent observer)	intervention - traditional teaching	intervention - activity-based inquiry-oriented teaching
week 2 - day 7	posttest - achievement - attitude	posttest - achievement - attitude
week 3 - day 7	delayed posttest - achievement - attitude	delayed posttest - achievement - attitude

The independent variable

The independent variable of the study was the method of instruction. The conceptual understanding and attitudinal change following the intervention, was used to find out the comparative effectiveness of the two teaching approaches in promoting these features. However, there are many other elements that could have affected the study such as the teacher, grouping of the students, history and maturation. Attempts at minimising these effects are discussed as part of the limitations.

The dependent variables

The dependent variables investigated in this study were students' understanding of the concepts related to balance and the changes in students' attitudes toward science. The effect on these variables were observed at three different instances.

During the initial planning stages of planning this study an investigation of the teacher's attitude towards the activity-based, inquiry-oriented teaching approach and curriculum materials was intended. However the above mentioned approach was implemented by the researcher due to the classroom teacher's insecurity in effectively implementing the new approach.

The Curriculum package

The curriculum package developed for this study was produced by the author (Appendix A) based on part three of the detailed scheme of work (forces) of the Grade Eight Physics Foundation Course (Appendix C). The package was validated through expert appraisal. This course was developed for use in Maldivian Schools by the Physics Teachers'

Committee of the Maldives. The aim of this course is to prepare students for the London Ordinary Level General Certificate of Examination, which is an external examination.

Research outlined in the literature review has shown that activity-based, inquiry-oriented approaches to teaching, foster the acquisition of knowledge, and positive attitudes. The need for science curricula to provide experiences that promote aspects of student development such as processing skills were emphasised by Yager (1984) and Fensham (1987). Furthermore they have asserted the importance of providing relevant science experiences for students, after examining the effects of different curricula on student performance.

Different cultures have different social and environmental characteristics that effect the learning of science (Jegede and Okebukola, 1991, p. 276). Hence experiences relevant to another culture would not necessarily be so to the Maldivian culture.

The only teacher support material available in the Maldives other than the introductory notes of the Grade Eight Physics Foundation Course are textbooks. All texts currently used in teaching this course were developed in Western countries (Pople, 1984). Therefore the equipment and examples used are alien to the Maldivian way of life. Conversely, the curriculum package that was developed for this study employs local materials.

Furthermore the Grade Eight Physics Foundation Course has another failing in that it tends to foster the lower Bloom levels of learning. Most of the objectives outlined fall into the knowledge and comprehensive levels of the cognitive domain. Inquiry-oriented work requires the student to be able to work in the higher Bloom levels. Therefore although the

introductory notes of the Grade Eight Physics Foundation Course support the use of inquiry in teaching. The detailed scheme of work does not mirror this recommendation.

Although the Grade Eight Physics Foundation Course encourages the use of inquiry, practical activities and improvised, locally available equipment, the detailed schemes of work produced for the implementation of the Foundation Course does not provide teacher support for such changes. In order to cater for these aspects, the curriculum developed for this study utilised locally available, simple equipment used in the students' everyday life in an activity-based, inquiry oriented approach to teaching.

More specifically, the curriculum package was developed to cover ten, thirty minute lessons. Specific objectives were developed for each lesson based on the general objectives included in part three of the detailed scheme of work of the Grade Eight Physics Foundation Course. Explanatory teacher notes and student worksheets for each lesson are included. The materials needed for each lesson are also listed in the respective worksheets. Comprehensive annotated diagrams and instructions are used in the worksheets to provide guided experiences of an inquiry nature. The worksheets were prepared so that they could also be used as lesson plans, and therefore provide much needed teacher support material.

The instruments

The achievement test.

This test (Appendix D) consists of a variety of test items including open ended, short answer and multiple choice questions, which were used to measure student achievement. Andre (1990) found that the processing of information was required for application questions. These items tested concepts related to the balance at the lower and higher Bloom

cognitive levels. Concept validity and sample validity of the test was determined by expert appraisal. Pre, post and delayed posttest scores were obtained through the administration of this test.

Reliability of the test was determined by computing student test scores for pre, post and delayed posttest using Cronbach's Alpha. A split half correlation of 0.83 indicated the internal consistency of the test, justifying the use of Cronbach's Alpha as a measure of reliability, which was found to be 0.6.

At first glance, this instrument appears to have a low reliability. However reliability is strongly dependent on test length, making it extremely hard to obtain high coefficients with less than ten test items. Further computations revealed an additional five test items of the same standing would have increased the coefficient to 0.7, thus indicating the inherent reliability of the test. Furthermore Linn (1988) asserts that a low reliability of about 0.6, though low for purposes of making individual decisions, is certainly more than adequate for determining the magnitude and direction of change for a group as a whole. Hence, the reliability obtained for the achievement test is sufficient for the purpose of comparing the effectiveness of the two teaching approaches used.

Student Attitude test.

Students from both groups were tested after the intervention. The instrument (Appendix E) used a Lickert scale to investigate the students' enjoyment of science, confidence in their interpretations of what they were supposed to learn in the lessons, their attitudes towards the equipment used (in terms of the perceived effect on student understanding and usefulness); and the preferences for the teaching method used.

Reliability was ascertained through the computation of student score of pre, post and delayed posttesting to be a low 4.9. This was not unexpected due to the length of the test. Furthermore low reliability is characteristic of attitude tests.

Procedure

The organisation of the school.

The study was aimed at comparing the effectiveness of the teaching approaches at a government secondary boys' school. However due to the administrative difficulties encountered, a private boys' school was chosen on the basis of willingness of the school to collaborate.

Briefing the staff and the students.

The principal and teachers involved were provided with copies of the curriculum package and a summary of the research design. A discussion session was organised a week after the above mentioned materials were supplied to discuss the issues involved. Students in both groups were exposed to the Hawthorne effect when they were informed of their involvement in the project. It was hoped that the consequences of the Hawthorne effect would be minimised by exposing both groups to the effect.

Pretesting.

Student attitudes were tested during the first lesson using the attitude test instrument. The achievement test was administered after the attitude test so that students' inability to answer the questions would not affect their attitudes.

The intervention.

The following two weeks were spent by both teachers in teaching the concepts covered by the general objectives outlined in the curriculum package (Appendix A). The traditional group was taught by their classroom teacher using the traditional approach. The inquiry group were instructed by the researcher using the activity-based, inquiry oriented approach.

Posttesting.

The posttest was administered to both groups during the lesson following the conclusion of the intervention. The attitude test was conducted first, followed by the achievement test

Delayed posttesting.

The delayed post achievement and attitude tests were administered a week after the termination of the intervention. It was hoped that this administration would produce a more accurate estimation of the reliability of the instruments.

Data Analysis

The achievement test.

The scores obtained for the different items on the test were totalled for each subject for the pre, post and delayed posttests. Mean scores and standard deviations were computed in each group for each test. A t-test was used to determine the differences in pre, post and

delayed posttest mean scores between the students in the traditional and inquiry groups. Differences between the mean pre and posttest mean scores were also established for each group by using a t-test.

The student attitude test.

Scores were totalled for each subject on each test. Mean scores were calculated. A t-test was used to compare the differences in student attitudes between the two groups on each test, and within the groups between the pre and posttests.

Limitations of the study

Internal validity.

Internal validity depends on how much the experiment can be controlled for variables other than the independent variable (Gay, 1992). Maturation, historical and pretesting factors are possible determinants that could effect the results. The use of the control group permits the changes resulting from these factors to be accounted for.

A further limitation of the study was the fact that the inquiry and the traditional groups were taught by different teachers. It is believed that the preferred teaching style of the teacher could have affected their teaching of the different approaches. To overcome this limitation the teachers were matched to their preferred styles of teaching.

Although this assignation aimed to reduce the effect of the teacher on the study, it remains a significant variable. The effectiveness of the implementation would be influenced by the strength of the teachers preference for the approach.

External validity.

External validity requires the experiment to take place in surroundings as natural as possible (Gay, 1992). Attempts to increase the external validity of the study are outlined below.

The pretest was administered a day before the intervention, establishing sensitisation of the students to be a determinant of the results. Ideally, a longer period would be needed between the pretest and the intervention to desensitise the subjects to the intervention. However, as both groups were exposed to this effect, the consequences of this effect can be ignored. Significant difference in retention on the delayed posttest upholds the lack of significance of the sensitisation.

The selection of a particular school caused selection-treatment interaction to be a barrier to the generalisability of the study. This school was chosen on the basis of it's willingness to collaborate and it's economic standing. The school lacked sufficient funds to procure enough laboratory equipment to maintain a well-equipped laboratory. Therefore it was hoped that the results obtained through this study could be applied in the planning of the new schools on other islands, for more efficient resource management, thereby providing a certain level of generalisability.

Hawthorne and novelty effects resulting from presentation of the new curriculum to the inquiry group by a new teacher affected the generalisability of the findings. The Hawthorne effect was minimised by informing both groups of their involvement in the research; yet the novelty effect remained a limitation of the study.

Summary of the chapter

A quasi experimental, non equivalent control group design was used in the study to investigate the effects of the two different teaching approaches on student achievement and attitude. As a result of constraints imposed by the school organisation there are limitations in certain aspects of the study. Measures were taken in an attempt to minimise the effect of these limitations on the results of the study. A detailed activity-based program relevant to the Maldivian context was developed for the study.

Chapter 4

Results

Overview

The results of the study have been presented for each of the research questions. General trends and significant results are discussed in this chapter.

Pre, post and delayed post achievement test scores of the treatment and control groups have been discussed in relation to Research Question 1, which is related to the effectiveness of the two teaching methods.

The effect of the two teaching approaches on student attitudes has then been analysed, based on the results obtained from the pre, post and delayed post administrations of the questionnaire. Research question 2 was addressed through this discussion. Further analysis of the different aspects that were investigated concerning student attitude have also been included.

Research question 1

"Does inquiry-based, activity-oriented, teaching of the nature of balance using simple equipment lead to higher achievement levels than a traditional teaching method?"

Pretest.

There were no statistically significant differences (at the $p= 0.05$ level) in student achievement levels on the pretest between the traditional and inquiry groups as shown in Table 4. The mean scores for the achievement test were low as anticipated, as students

had yet to be 'taught' the concepts of balance. The traditional group had a lower mean score than for the inquiry group which was unexpected as the traditional students had been deemed the more 'academically able' of the two groups on the basis of former evaluations (Table 5).

Table 4

Statistical differences between the levels of achievement of the inquiry and traditional groups on the pretest

t Value	Degrees of Freedom	2-tail probability
-1.14	65	0.260

Table 5

Mean achievement pretest scores

Group	Number of cases	Mean	Standard deviation	Standard Error
Traditional	32	2.85	1.793	0.317
Inquiry	35	3.38	1.978	0.334

Hence, the assumption of the similarity of the understanding of the nature of balance of both the treatment and control groups has been justified.

Posttest.

Posttest scores on the achievement test showed no statistically significant differences in achievement between the two groups (Table 6). Therefore the intervention had produced similar levels of achievement in both groups.

Table 6

Statistical differences between the level of achievement of the inquiry and traditional groups on the posttest

t Value	Degrees of Freedom	2-tail probability
-1.14	52	0.165

Table 7

Mean achievement posttest scores

Group	Number of cases	Mean	Standard Deviation	Standard Error
Traditional	25	5.72	2.305	0.461
Inquiry	29	6.69	2.701	0.501

However statistically significant differences were present between the pre and posttest scores of the traditional and inquiry groups as shown in Tables 8 and 9 respectively . The mean scores for the pre and posttests (Tables 10 and 11) indicate that both groups had a better understanding of the nature of balance than they had at the time of the pretest.

Table 8

Statistical differences between pre and posttest achievement levels of the traditional group

t Value	Degrees of Freedom	2-tail probability
-5.27	55	0.000

Table 9

Statistical differences between pre and posttest achievement levels of the inquiry group

t Value	Degrees of Freedom	2-tail probability
-5.64	62	0.000

Table 10

Mean pre and posttest scores for the traditional group

	Number of cases	Mean	Standard Deviation	Standard Error
Pretest	32	2.86	1.793	0.317
Posttest	25	5.72	2.305	0.461

Table 11

Mean pre and posttest scores for the inquiry group

	Number of cases	Mean	Standard Deviation	Standard Error
Pre-test	35	3.39	1.978	0.334
Posttest	29	6.69	2.701	0.501

Delayed posttest

The results of the delayed posttest produced statistically significant differences in achievement between the two groups as shown in Table 12. The mean score for the inquiry group was higher than that for the traditional group (Table 13). This established that the retention of the concepts related to the nature of balance was higher in the treatment group than the control group.

The mean score for the traditional group was a low 4.64 (33% of the highest possible score) compared to the higher mean score of 6.32 scored by the inquiry group (45% of the highest possible score).

Table 12

Statistical differences between the level of achievement of the inquiry and traditional groups on the delayed posttest

t Value	Degrees of Freedom	2-tail probability
-2.56	60	0.13

Table 13

Mean achievement delayed posttest scores

Group	Number of cases	Mean	Standard Deviation	Standard Error
Traditional	31	4.64	2.328	0.418
Inquiry	31	6.32	2.800	0.503

General trends

Teaching the concepts related to balance using a traditional approach resulted in doubled achievement scores for the traditional group. However after a week, the

students' achievement dropped by 18% indicating that only 82% of the learning had been retained.

The treatment administered to the inquiry group (the new teaching approach) produced a slightly smaller increase in the level of achievement (a 97% increase). On the delayed posttest which was administered a week later, this group was found to have retained 95% of what they learnt during the treatment (Figure 5).

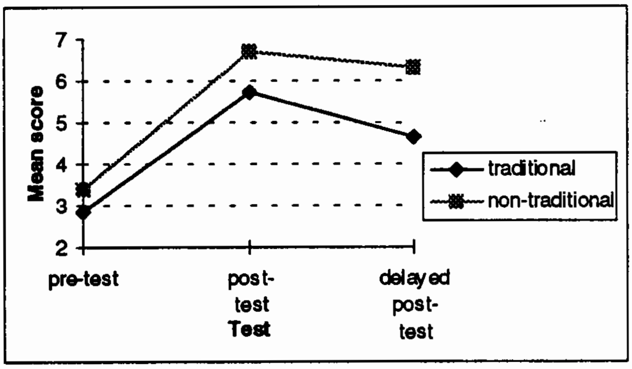

Figure 5. Changes in the levels of achievement across the observation period

Research Question 2

"How does activity-oriented, inquiry-based teaching using simple equipment affect student attitudes towards science compared to traditional teaching?"

Pretest.

No statistically significant differences were observed between the attitudes of the two groups prior to the intervention period (Table 14). All students had relatively positive attitudes towards science as shown by the mean scores obtained (Table 15). The traditional group showed a greater range in attitudes than the inquiry group on the attitudinal pretest.

Table 14

Statistical differences between student attitudes of the inquiry and traditional groups on the pretest

t Value	Degrees of Freedom	2-tail probability
0.25	52	0.803

Table 15

Mean attitude pretest scores

	Number of cases	Mean	Standard Deviation	Standard Error
Traditional Group	30	18.43	2.800	0.511
Inquiry Group	24	18.25	2.507	0.512

Posttest.

Posttest attitude scores of the two groups were not statistically significant as indicated by Tables 16 and 17. Therefore the effectiveness of both teaching approaches in fostering positive attitudes towards science, as a result of a two week intervention period appear to be equal. Further analysis of the data revealed that both groups had not significantly changed their attitudes towards science since the start of the investigation (Tables 18, 19, 20, 21).

Table 16

Statistical differences between student attitudes of the inquiry and traditional groups on the posttest

t Value	Degrees of Freedom	2-tail probability
-1.07	55	0.291

Table 17

Mean attitude posttest scores

	Number of cases	Mean	Standard Deviation	Standard Error
Traditional Group	26	17.65	4.270	0.837
Inquiry Group	31	18.81	3.894	0.699

Table 18

Statistical differences between pre and posttest student attitudes of the traditional group

t Value	Degrees of Freedom	2-tail probability
0.82	54	0.417

Table 19

Statistical differences between pre and posttest student attitudes of the inquiry group

t Value	Degrees of Freedom	2-tail probability
-0.61	53	0.545

Table 20

Mean pre and posttest scores for the traditional group

	Number of cases	Mean	Standard Deviation	Standard Error
Pretest	30	18.43	2.800	0.511
Posttest	26	17.65	4.270	0.837

Table 21

Mean pre and posttest scores for the traditional group

	Number of cases	Mean	Standard Deviation	Standard Error
Pretest	24	18.25	2.507	0.512
Posttest	31	18.81	3.894	0.699

Delayed posttest.

Statistical analysis of the delayed posttest scores showed that attitudes had not changed significantly in the period between posttesting and the delayed post administration (Tables 22 and 23). The mean scores obtained are higher than for the pre or posttests in both groups, but not significantly so.

Table 22

Statistical differences between student attitudes of the inquiry and traditional groups on the delayed posttest

t Value	Degrees of Freedom	2-tail probability
-0.09	57	0.925

Table 23

Mean attitude delayed posttest scores

	Number of cases	Mean	Standard Deviation	Standard Error
Pretest	24	19.30	3.229	0.589
Posttest	31	19.37	3.223	0.598

Student enjoyment of science.

Student enjoyment of science was generally high for both groups prior to treatment. Students in the traditional group experienced a temporary reduction in enjoyment of science due to the two week intervention. Nevertheless, enjoyment of science was observed to have increased a week later . Student enjoyment of science in the inquiry group remained relatively stable over the period of observation (Figure 6).

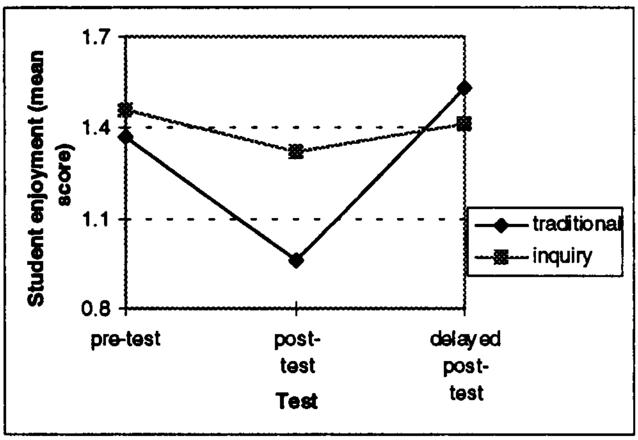

Figure 6. Changes in student enjoyment of science across the observation period

Student confidence in their interpretation of what they were supposed to learn.

Observation of change in student confidence in the interpretation of what they were supposed to learn during their science lessons revealed that in the traditional group, student confidence stayed relatively unchanged as a result of the intervention and did not vary on termination of the treatment. Students in the inquiry group displayed increasing confidence throughout the treatment and post-treatment periods (Figure 7).

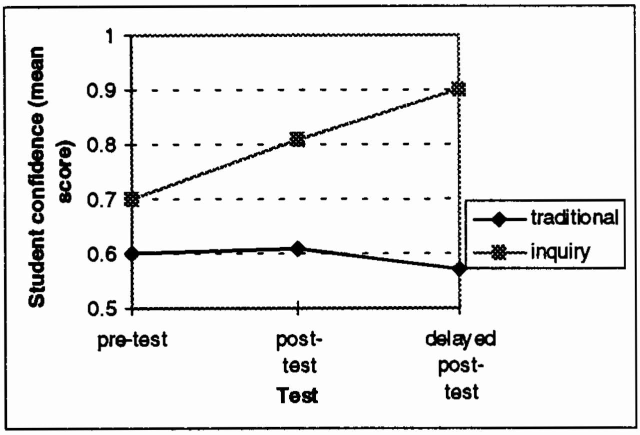

Figure 7. Changes in student confidence in their inetrpretations of what was to be learned in science lessons

Student perceptions of the usefulness of the science taught in the classroom.

Prior to the intervention period, students in the traditional group perceived what was taught in their science lessons as quite useful . Posttest results showed their positive attitudes to have diminished considerably during the treatment and to have recovered to some extent during the post-treatment period. The inquiry group experienced a continued increase in their perceptions of usefulness of what they were taught in science throughout the observation period (Figure 8).

Students' perceptions of the effect of the use of equipment on student understanding.

Prior to treatment, students in the traditional group felt that the equipment used increased student understanding to a certain extent. The inquiry group did not view the

effect as being quite so significant. Attitudes of students in the inquiry group remained fairly constant through the treatment and post-treatment periods while those in the traditional group changed their opinion in favour of the equipment used (Figure 9).

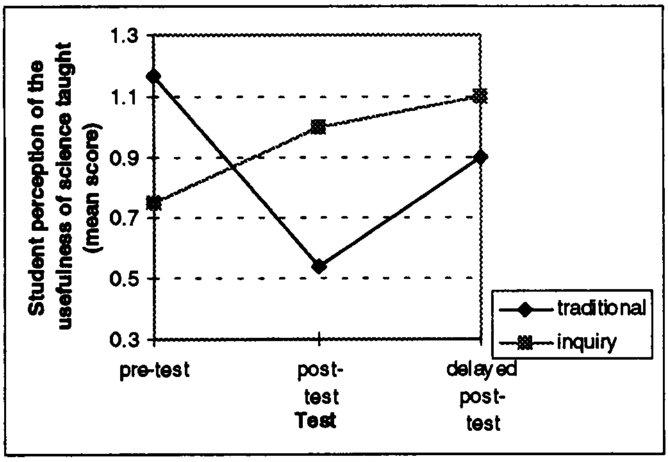

Figure 8. Changes in student perceptions of the usefulness of the science taught in science lessons

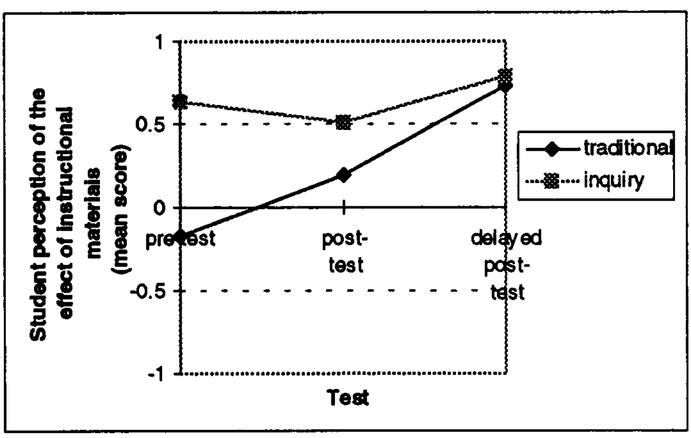

Figure 9. Student perceptions of the effect of instructional materials in increasing understanding

Student preference for the teaching approach used.

Students in the traditional group liked the teaching approach that was used throughout the period of observation. Those in the inquiry group expressed their dislike of the approach used prior to treatment. However their preference for the approach used

during the treatment and post-treatment periods were higher than that for the pre-treatment period as shown in Figure 10.

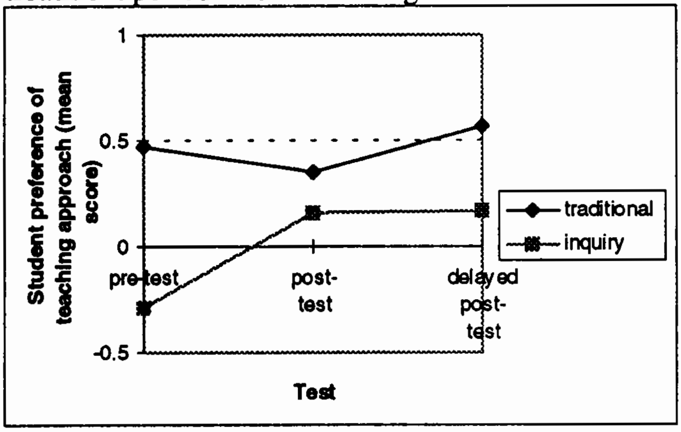

Figure 10. Students' preference of the teaching approach used.

General trends.

Although attitudes remained positive and relatively constant throughout the period of observation, the traditional group experienced a slight 4% decrease in positive attitudes towards science during the intervention. A week later, student attitude displayed a 9% growth in positive feelings towards science. Students in the inquiry group sustained a 3% rise in positive attitudes during the entire period of observation (Figure 11).

Supplementary results

This section of the chapter is allocated to summaries of observations made by the researcher during the implementation of the inquiry-oriented, activity-based approach. It is hoped that these accounts will help contextualise the study and provide more insight into the data obtained on the tests.

One of the most significant observations made was regarding the awareness of the school population about the implementation of the new curriculum. Due to the

cramped nature of the school buildings and the size of the school population, the whole school, both staff and students were aware that one group of students was exposed to a new activity-based approach to teaching. The nature of the materials used in the approach was much discussed by staff and students. The staff viewed the use of these materials and the new approach with amused tolerance as the 'efforts of a young, enthusiastic teacher '. On the other hand the students regarded the materials used with a mixture of scorn and interest. Quite a few students who were not in the inquiry group expressed their desire to try the activities that they had heard about from those in the inquiry group.

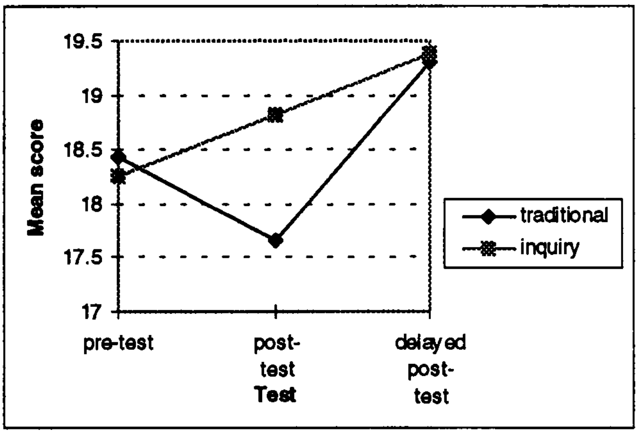

Figure 11. Changes in student attitude across the observation period

In the initial stages of the implementation of the new approach, students were a bit slow in getting started on the designated activity for the lesson. Once they were given the equipment, they spent a few minutes playing with the equipment and were a little unsure of what they were supposed to do. However by the second week of the implementation, students were on task and confident about what was expected of them.

Another interesting observation was related to the number of questions and conjectures expressed by the students. At the start of the implementation, students were extremely passive and carried out the teachers instructions to the letter. It was observed by the end of the implementation that students were asking more questions and speculating about the results of the activities.

Finally, the limited English vocabulary of the students was a recognised barrier to the effective implementation of the inquiry approach. Students in the inquiry group had difficulty expressing themselves in English. For example, in lesson one, students were asked to explain what had happened during a demonstration. None of the students were able to do so in English. However, they had no difficulty in explaining the demonstration in Dhivehi (the local language). This aspect was also evident in their answers on the pre, post and delayed posttests.The observations described above were confirmed with the independent observer who verified the teaching approaches.

Summary of the chapter

Traditional teaching and activity-oriented, inquiry-based teaching using simple equipment led to similar levels of achievement. However the latter approach appeared to be more effective in promoting the retention of the concepts learned.

On the whole, no long term effects were observed for student attitudes in either group. Specifically, student enjoyment of science of the traditional group decreased immediately after the intervention period, though no long term changes were observed for either group. Student confidence in their interpretations of what they were supposed to learn increased progressively for students in the inquiry group and remained constant for those in the traditional group. Students in the inquiry group perceived the science taught in their lessons in the observation period as being progressively more helpful, while a temporary loss was felt by those in the traditional group immediately after the intervention. Both groups were increasingly of the opinion that the instructional materials used during teaching, enhanced their understanding regardless of the approach used. Finally, student preference for the activity-based, inquiry-oriented approach by the inquiry group increased during the intervention while preference for traditional teaching remained constant for students in the traditional group.

Chapter 5

Discussion

Achievement

Pretest.

Pretest results showed that there were no significant differences between the two groups. The achievement level results of the traditional and the inquiry groups on the application-based achievement test were contrary to expectations. Since the groups were originally formed on the basis of academic abilities, there could be a number of reasons for these results.

The maturation rates of the two groups could have been different. This could have induced a faster rate of maturation for students in the inquiry group between the last evaluation of academic ability and the pretest.

Differences in the nature of the tests used in the two evaluations can also explain the above mentioned result. The test used earlier could have tested a different concept or ability to that tested by the pretest. Hence the pretest only confirms that students in both the traditional and inquiry groups have a similar understanding of the concepts related to balance.

Posttest.

The results of the posttest revealed no statistically significant differences in achievement between the two groups. Considering the number of studies which showed high content achievement as a result of the implementation of inquiry-oriented (Hall and

McCurdy, 1990; Rubin and Tamir, 1988; Shymansky, Hedges and Woodworth, 1990; Doty, 1985), activity-based (Mensch and Rubba, 1991) or a combined approach (Fuller, 1987; Ohanenye, 1986) to teaching science, it was surprising to have found results that were inconclusive in establishing the effectiveness of the inquiry-oriented, activity-based approach.

A very important element that could have produced a result so contrary to those found in the studies examined was the length of the intervention. The briefness of the period of intervention (two weeks) could have been too short a time-span for students to have overcome the initial acclimatisation period.

The results also failed to support the findings of Fowler and Mulapo's study (1987), which revealed that the traditional approach was more effective in promoting achievement than the inquiry approach in promoting achievement. Instead the results on the posttest appears to confirm the equal effectiveness of both the traditional and inquiry approaches in increasing achievement. This outcome can be accounted for by Andre (1990, p. 81). He postulated that when a posttest immediately follows the study of some material, students may be able to recall the text sufficiently well so as to infer or deduce the answers to new application questions. Therefore an immediate posttest might not differentiate between students who have used factual recall methods to answer the questions and those who have built meanings for and processed the information gained during the instruction.

Even (1977) and Tjosvold (1977) cited in Fowler and Mulapo (1987) propose another determinant that could have influenced the result. They maintain that activity-oriented instructional approaches may not be effective when used with learners who have been previously exposed to the textbook approach. Students who have been used to text book or lecture methods are not used to reformulating their ideas or teacher instructions to activities. Long accustomed to teacher-directed methods of instruction, students have

little predisposition and confidence in self-discovery and inquiry (Tan, 1991, p. 247); hence the lack of difference in achievement when an activity-based approach is used for students used to traditional teaching.

Furthermore Fowler and Mulapo (1987), based on their findings, state that the instructional mode does not make a difference to concrete reasoners in their understanding of science. Although the possibility of all students being concrete reasoners is extremely low, this possibility cannot be totally dismissed unless it is proven otherwise.

As the above conjectures were not comparatively tested for their effect on student achievement when used with traditional and inquiry approaches to teaching, these areas are recommended as possible areas for further study.

Delayed posttest.

The results on the delayed posttest revealed high retention in both groups. This is in accordance with the results obtained on a study carried out by Semb and Ellis (1994). Nevertheless for the inquiry group the retention was significantly higher (95% of the original learning) than that for the traditional group (82% of the original learning).

These results are supported by Conway, Cohen and Stanhope (1991) and Mackenzie and White (1982), cited in Semb and Ellis (1994). They attributed the higher retention levels in students involved, to the active nature of learning.

Semb and Ellis also looked at how the retention of different learning tasks were affected over time by using a meta analysis of such studies. They found that the loss of recognition of concepts learned is lowest between one and four weeks after the intervention compared to recall and higher order cognitive skills. Cognitive skills in this

meta-analysis refers to tasks such as problem solving, concept identification, analysis, comprehension, rule using , diagnosis, prediction, explanation and classification- and is related to understanding of the concepts.

This is consistent with the results of this study and Andre's findings (1990, p. 84) that subjects used to answering factual questions given a delayed posttest, had forgotten some of the information and were less likely to infer answers to new application questions.

According to Semb and Ellis (1994), retention is affected by what happens to the learner during the length of the retention period. The marked reduction of retention in the achievement levels of the traditional group can be explained using the information processing model of learning (Biggs and Moore 1993, p. 207). It is assumed that some amount of information processing takes place during the retention period. The information gained by the students in the traditional group is not associated with the learning or schemas present in the long term memory as students are passive acceptors of teacher presented facts in this context. Hence movement of the information accepted to the long term memory is not facilitated (Woolfolk, 1993, p. 249). Therefore the information can only be used in recognition or recall but not in higher level cognitive activities.

The higher achievement levels of the inquiry group on the delayed posttest is concordant with Andre's findings (1990). He discovered that doing application questions induced different, more stable memory structures to be created than by attempting factual questions. In the inquiry approach, students employed application questions to manipulate the materials in order to construct their own schemas. The approach required students to associate old information with the new so that they could build meaning for the new information that has been acquired. This active construction of meanings necessitates information processing. Consequently permanent storage of the new

information in the long term memory becomes possible (Woolfolk, 1993, p. 249); hence the significantly higher achievement levels on the delayed posttest.

Another possible reason for the above result has been suggested by Glasson (1989, p. 129), who states that hands-on activities promote peer interaction which plays an important role in the equilibration process by stimulating conceptual conflicts based on the errors made by the students. This is in agreement with the constructivist viewpoint (Saunders, 1992, p. 136). He explains further that students are more likely to learn from their own errors than through the authority and judgement of the teacher. As the inquiry approach implemented in the study involves hands-on activities, the results on the delayed posttest are justified.

It is also conceivable that the indigenous nature of the materials used created stronger links to prior knowledge of the materials used due to their familiarity; thereby facilitating extended processing of the new information obtained, leading to longer retention. Swift (1992, p. 7) emphasises this notion which was discussed at length in a conference in Thailand on Indigenous Knowledge and Learning in 1989. He asserts that the greater the indigenous knowledge and the less the imported knowledge, the greater the likelihood that the latter will be assimilated and used. In this study, the indigenous knowledge is seen as prior knowledge associated with the indigenous, local materials used to teach the inquiry group through the designed curriculum package. The imported or new knowledge is viewed as the concepts learned during the intervention period. This argument can be consolidated by a review of the development of Secondary School Science Curriculum in Malaysia (Tan, 1991).

Three British Science Curricula, namely, The Scottish Integrated Science Syllabus, The Nuffield Secondary School Science Curriculum and The Nuffield 'O' Levels Pure Science Syllabi were adopted in 1968 by the Malaysian Secondary Education system. This adoption proceeded through to 1981. Swetz and Meerah (1982)

cited in Tan (1991, p. 245) discovered that Malaysian students had trouble seeing the relevance of examples and experiments found in the science texts to their experiences in everyday life. Students in rural areas found the scientific equipment and materials used in laboratory experimentation too alien and advanced to help establish the desired concepts.

As curricula previously used in the Maldives has been similar to that described above, and because most of the students in private secondary schools on Male' come from other less developed islands, it was not surprising to find that the use of locally available materials in the teaching of science had generated greater retention of the concepts in the inquiry group as a result of students' constructions of their own meanings.

The results of the delayed posttest compared to those of the pre and posttest showed valid and comprehensive data with regard to the literature. Therefore the greater achievement of the students exposed to the activity-based, inquiry-oriented approach using simple, locally available equipment, can be attributed to the nature of the processing of the concepts taught and to the indigenous distinction of the materials used for the instruction.

Student Attitudes

General.

On the whole, no significant effects on student attitude were detected for either group as a result of the intervention. This effect does not agree with the majority of the research reviewed.

Of the studies surveyed, most showed an increase in positive student attitudes as a consequence of inquiry-oriented (Kyle, Bonnsetter and Gadsden, 1983; Paul and

Germann, 1987; Shepardson and Pizzini, 1993), activity-based (Mensch and Rubba, 1986) or a combined approach (Ohanenye, 1986; Fowler and Mulapo, 1987) to teaching science.

Explanation of the results of this study can be attempted based on Abunajmeh's (1985) and Shymansky, Hedges and Woodworth's (1990) studies. They found that attitudes of students in lower secondary schools are not affected positively by inquiry-oriented teaching methods. However Shepardson and Pizzini (1993) and Mensch and Rubba (1986) contradicted this outcome. Therefore it is assumed that some other unexplained factor similar in both studies produced the similar results.

Different levels of inquiry require the student to have different levels of autonomy over the activities that are carried out (Hegarty). So, another conceivable factor which could have affected student attitudes is the level of inquiry employed in the approach as supported by Tan (1991, p.247). However Hall and McCurdy (1990) found that this was not the case. Hence stability of student attitudes in this study are not attributed to the level of inquiry used.

Jegede and Okebukola's' study (1991) offers an explanation of the lack of increase in positive attitudes by students of the inquiry group in this study. Male', the capital where the study was conducted, can be described as an urban area. Schooling has remained traditional. Due to the lack of space most people have turned towards more sedentary pastimes (such as television) in preference to the more dynamic activities preferred by the people in other atolls. Furthurmore, students are generally more dependent on factual knowledge obtained from books and other instructional media which requires the student to play a passive role. This provides a probable explanation of why students in the inquiry group are not positively predisposed towards the inquiry approach that was used in the study.

Shymansky, Hedges and Woodworth's results (1990) suggested that the ability of inquiry-based curricula to promote student attitudes towards science is affected by the level of urbanisation of the school. This is further explained by Jegede and Okebukola's study (1991) which established that the use of socio-cultural modes of instruction increases positive attitudes towards science. Socio-culture is explained by Jegede and Okebukola (1991, p. 275) as a commonality in values, appreciation of beliefs, customs, myths etc. A lot of these values, beliefs, customs and myths originate from the construction of meanings for natural phenomena based on previous observations and experiences of the environment. This type of interaction with the environment is generally present in rural societies. Hence, students in rural schools would be more positively influenced towards an inquiry approach (which involves this type of interaction) than those in an urban school.

Tan (1991, p. 247) implied the relative stability of attitudes over long periods of time. Since the period of intervention was very short (two weeks), it was not surprising to find that student attitudes had not changed. It is felt that this factor was a very important determinant of student attitudes in this study.

Kempa and Diaz (1990) suggest another possible reason why the inquiry-based of the new approach might not have increased positive attitudes towards science in this study. They believe that students have motivational orientations which classify them as either achievers, curious, conscientious or sociable, based on the student's need to achieve, satisfy one's curiosity, discharge a duty and to affiliate with other people respectively.

Investigation of the relationship between motivational orientation and students' perceptions of instructional approaches in the same study revealed that students with an achiever orientation favoured formal teaching, while those curiously oriented strongly preferred the discovery (inquiry) approach for knowledge acquisition. The sociable

students were found to possess a moderate partiality towards the discovery (inquiry) approach while those belonging to the conscientious group were biased towards formal teaching.

In order to reason the outcomes of this study, Kemp and Diaz's findings on students' views of practical work are also important . The curiously oriented students strongly favoured doing practical work; but disliked experiments which were not student owned. Practical work was indirectly perceived positively by sociably oriented students while conscientiously reconciled students tended to like guided experimental work.

This information is in accordance with the student preferred teaching methods for knowledge acquisition which puts forward the possibility that the students in the inquiry group in this study were conscientiously oriented. If this is true, students would view the learning of science as a duty that needs to be discharged and prefer a teacher-centred environment. This explanation consequently rationalises the lack of change in student attitudes.

The aspects discussed in this chapter so far propose that the relatively stable attitudes resulting from the intervention were due to the dissimilarity of the socio-cultural characteristics of the students and the inquiry approach, the shortness of the period of intervention and/or the motivational orientation of the students. Studies need to be carried out in the Maldivian context as socio-culture appears to be a significant determinant of changes in student attitudes (Jegede and Okebukola, 1991).

Changes in student enjoyment of science, confidence in their interpretations of what they were supposed to learn; perceptions of the usefulness of science taught in the classroom and the effect of the instructional materials in increasing student understanding and students preference of the teaching approach used were monitored

throughout the study in order to obtain a clearer picture of the change in student attitudes.

Student enjoyment of science.

The use of the inquiry-based approach produced no significant increase in positive attitude in the inquiry group on the post or delayed posttests. This can be explained by Kempa and Diaz's (1990) student orientation classification and characteristics present in the society.

The Maldivian community is authoritarian in nature. Younger people are expected to respect and obey their elders to a much greater extent than is the case for a western society. Ismail (1993, p. 8) described other factors that individualise the Maldivian society as the close-knit structure of the family and the style of living which borders on communal. Due to this type of living arrangement, every individual in the family has duties allocated to them. These duties are carried out under the supervision of the older members of the family. This family structure accounts for the probable conscientious nature of the students and hence illustrates why enjoyment of science of students in the inquiry group were not enhanced.

The analysis of the data revealed a temporary decrease in student enjoyment of science for students in the traditional group on the posttest (Figure 6). It is felt that this was due to students' awareness of the implementation of the new approach.

Student confidence in their interpretations of what was to be learned in science lessons.

Students in the inquiry group became increasingly confident about what they were supposed to learn in science, although no change was observed for those in the

traditional group. One possible reason for this result can be the indigenous nature of the materials used in the instruction. Swift (1992, p. 7) asserts that the use of indigenous knowledge increases the likelihood of assimilation of new information. Indigenous knowledge can be described as knowledge associated with the specific culture. The context in which student attitudes were developed are related to the knowledge associated with the indigenous materials found in their environment. Hence, past experiences with these materials provide students with a bank of prior knowledge and an indication of the possible outcomes of manipulating the materials. The high level of confidence observed in students of the inquiry group, in their interpretations of what they are supposed to learn is hardly surprising.

Student perceptions of the usefulness of science taught in science lessons.

Students exposed to the inquiry-oriented curriculum experienced a continued increase in the usefulness of the science content taught. This effect can be clarified further by Swetz and Meerah's findings (1982, cited in Tan, 1991, p. 245). They suggested that irrelevant science teaching hindered the acquisition of science concepts. Conversely these results suggest that relevant science teaching would foster science learning. The following discussion is based on this assumption.

It is conceivable that the teaching employed in the new approach increased students' perceived usefulness of the science taught on the posttest as a result of the relevance of the materials used to their everyday lives. The continued increase on the delayed posttest can be explained by the proposition that once the relevance of science taught is established, students learn to make links between the science they learn and their everyday life regardless of the teaching approach used.

The sudden drop in perceived usefulness of science in the traditional group on the posttest scores can be attributed to student awareness of the implementation of the

new approach and the assumption mentioned above. Students' comparison of the materials used in the inquiry and traditional groups in relation to the relevance to their everyday life appears to have been the cause. The attribution of the results to student awareness of the implementation is justified by the rise in perceived usefulness on the delayed posttest a week after the intervention.

Comparison of the pre and delayed posttest scores for the traditional group showed that their perceived level of the usefulness of science taught in the classroom had dropped even though the intervention had ended. In accordance with Swetz and Meerah's results (1982) cited in Tan (1991, p. 245), students' exposure to what science teaching can involve in terms of relevance could have accounted for this dissatisfaction.

Student perceptions of the effect of the use of instructional materials on student understanding.

Students in the inquiry group felt that the equipment used in the new curriculum implementation did not increase student understanding on the posttest, while on the delayed posttest they indicated that the materials used in this period of time enhanced student understanding (Figure 9).

This result can be explained on the basis of a statement by a student in the inquiry group during the intervention. On receiving a potato to carry out an activity, he asked the teacher what sort of science could be learnt using potatoes instead of 'real' science equipment. This belief that the only equipment that can induce science learning of any worth as being the conventionally used laboratory equipment has important implications.

Swift (1992, p. 17) proposes that societal influences such as people's notions of knowledge transferral may affect the effectiveness of the use of indigenous knowledge in science education. As described earlier, in the Maldives, 'real' learning of science is

generally viewed by the locals as that which involves the use of the traditional approach used in this study with one or two verification laboratory demonstrations using the limited technical laboratory equipment imported from developed countries. Hence the status associated with the use of such equipment in science lessons is perceived to be significant in the eyes of the community; more so by students who had just completed intermediate schooling and have gained entry to the coveted high school level where they would usually get to see the teacher use 'real' science equipment.

It is therefore not surprising to find that the students in the inquiry group viewed the materials used in the inquiry approach as 'too' simple. Furthermore, they did not perceive these materials as tools which could promote student understanding.

The materials used by the teacher in the period between the post and the delayed posttests were perceived as having characteristics more conducive to understanding than those used in the inquiry-based teaching. This result lends itself to supporting the effect of the society's view of what 'real' teaching constitutes.

The awareness factor can be used to explain the gain in the traditional students' perception that the instructional materials used in the teaching of this group increased student understanding. If the inquiry group had reported the nature of the materials used in the new curriculum, student comparisons of the perceived status of such materials with that of the rarely used more complex, laboratory equipment would obviously ensure that observed effect of the materials used in the traditional approach to be high.

Student preference of the teaching approach used.

Students in the inquiry group viewed the traditional approach as an undesirable method of teaching even prior to the intervention. Posttest results showed that the new approach was seen more positively than the traditional one. These outcomes are in

agreement with those obtained for the perceived usefulness of science. Hence, the positive effect on student attitudes as a result of the indigenous nature of the materials appears to be substantiated. The maintained preference level on the delayed posttest advocates the proposition that when relevant materials are used, students start to make their own links between classroom science and the real world.

Once again results for the traditional group displayed the awareness effect. However student preference of the traditional approach remained relatively unchanged proposing the possible motivational orientation of the majority of the students to be that of the achiever type (Kempa and Diaz, 1990).

The results of the specific attitude analyses of the study proposes a number of ideas. Firstly, the limited student enjoyment of the new approach was attributed to the conscientious nature of the students in the inquiry group. The high student confidence of those in the inquiry group in the interpretation of what was to be learned was ascribed to the indigenous nature of the materials used as was the increase in the perceived usefulness of science. The materials used in the inquiry approach were not viewed as promoters of understanding. This result was attributed to the commonly held view of the status of the materials used.

At a glance, the explanation of the results of the perceived usefulness and the perceived effect of the materials used on understanding appears to be in conflict. A comparison of the way in which perceived relevance and perceived status affects students would explain the variance between the discussion of the two factors. For example, students might view some of the knowledge obtained at school as being useful to him/her personally. However the status associated with such knowledge could inhibit the student from displaying the value of the knowledge gained. Therefore, it can be seen that students perceptions of the usefulness of the materials used in the inquiry approach

does not contrast with their viewpoint regarding the effect of the materials on student understanding.

Finally, the strong preference of the inquiry students for the teaching approach used was ascribed to the relevance of the indigenous nature of the materials used. However, research needs to be done in the Maldivian context before these ideas can be substantiated as being relevant to this particular culture.

Supplementary results

Observations of the student population of the school during the period of intervention showed that the achievement and attitudes of students in the traditional group could be affected by their awareness of the implementation of the new approach. However results showed that this effect was not significant with regards to achievement or attitudes.

Another observation revealed that students in the inquiry group did not know what they were supposed to do during the initial stages of the implementation of the inquiry approach. Tan (1991, p. 247) proposed long term teacher-directed methods, inhibiting student confidence and disposition towards inquiry as the cause. This explanation is supported by subsequent observations, which disclosed that students became more confident of what they were supposed to do as well as becoming more actively involved in the learning process.

Finally, the students' difficulties in expressing their understanding of the concepts that were taught, needs to be discussed. English is the language used in secondary science instruction in the Maldives. The use of Dhivehi (the mother tongue) for any

purpose in the science classroom is disapproved of. Cummins (1978) cited in Garaway (1994, p. 104) states that the acquisition of academic language skills takes an average of five years. Therefore students who have newly arrived from other islands would have difficulty in dealing with the academic language used in the classroom as well as English, the language of instruction.

Muralidhar (1990) provides a more comprehensive explanation of some of the difficulties faced by students when taught in a language other than their mother tongue.

> The pupil has to cope with; his or her own language while writing notes or completing homework; teacher's spoken language; the language used in curriculum materials and textbooks; teacher's written language on the chalkboard, handouts and tests; the terminology of science; the disparity between the meanings of the same words when used in everyday language and when used in the context of a science lesson (p. 253).

Therefore it is hardly surprising that students in the inquiry group had difficulties expressing themselves in English.

Muralidhar's justification could also provide an explanation for the high retention of the concepts learned by the inquiry group. Students in this group had a chance to observe and to actively learn the concepts through a hands-on approach. Hence, they were able to overcome the language barrier by constructing their own meanings throughout the activities (possibly in Dhivehi) instead of having to build meanings from the teachers explanation of the concept in English. Consequently better retention was to be expected by the inquiry group as observed.

Recommendations for further research

It is acknowledged that the period undertaken for this study appears to be insufficient in establishing some of the possible relationships between the activity-based, inquiry-oriented teaching approach and student achievement and attitude. Hence it is felt that a similar study carried out over a longer period of time would reveal more justifiable conclusions.

Interesting notions that have arisen from the results of this study include the effect of urbanisation, the motivational orientations of students, socio-cultural aspects and language on inducing change in student attitude and possibly, achievement. It is believed that further research is necessary in these directions to produce a more comprehensive picture of the aspects that effect student attitudes and achievement in the Maldivian context.

Summary of the chapter

Better retention of concepts can be fostered in Maldivian students with the use of indigenous materials in an activity-based, inquiry-oriented learning environment. Therefore teaching in the science classroom can be made more effective in the long term with the use of the approach prescribed in this study.

However the effectiveness of this type of approach can be affected by socio-cultural characteristics and language. Hence the use of Dhivehi, especially during discussions, can help reduce problems associated with the language aspect. The use of English is recommended to rephrase these discussions so that students can practice expressing themselves in English once they have understood the concepts.

The effectiveness of this type of approach in teaching however, allows for the use of simple, locally available, inexpensive materials to present a more relevant science curriculum. Furthermore the implementation of such an approach has been shown by this study to be achievable and effective. The need for the development of such curricula for future educational development in the Maldives is apparent.

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Appendix A

The Curriculum Package

AN ACTIVITY-BASED, INQUIRY-ORIENTED, TWO WEEK MODULE ON BALANCE USING SIMPLE, INEXPENSIVE, LOCALLY AVAILABLE, EQUIPMENT.

(A MALDIVIAN APPROACH !)

GENERAL OBJECTIVES	LESSON	HANDS-ON-INQUIRY-BASED MODULE OBJECTIVES
At the end of the module, pupils will be able to:		At the end of the module, pupils will be able to:
1. apply the concept of "centre of gravity" to explain the stability of objects.	1. Introduction- (30 minutes)	observe thedifferences between balanced and imbalanced systems. - suggest reasons why a system is not balanced. - distinguish between a balanced and an imbalanced system.
	2. Designing a model (30 minutes)	- design a model of a stable monument - identify the features of the model that could affect it's balance.
	3. Is it really stable? (60 minutes)	- build the model of the monument as shown in the proposed plan. - explain how the height of the monument could affect it's stability. - modify the monument to make it more stable by changing it's centre of gravity.
	4. Why do objects fall over? (30 minutes)	- predict the approximate postions of the centre of gravity of objects with differing weight distributions. - explain how the base of an object affects it's stability. - decide how far an object can be tilted before it loses it's stability.
2. explain the "principles of moments", ie. the conditions for equilibrium when a number of parallel forces are acting on an object.	5. The rule of balance. (60 minutes)	- devise a rule governing the balance of an object through inquiry with a ruler.

3. apply the moments of force to explain the turning effect of a force.	7. Helicopters (60 minutes)	- identify the major forces acting in a real-life situation. - describe the results of changing (a) the distance between two parallel and opposite forces and (b) the size of two equal and opposite forces on the motion of the helicopter.
	8. Rotation (30 minutes)	- describe the different force arrangements that cause rotation of an object with (a) two parallel forces (b) one force.

MODULE ON BALANCE

Overview of the module

This two week module aims to provide a hands-on, activity-based setting in which students can learn the concepts of ***centre of gravity, moments of forces*** and ***couples*** through inquiry.

The main aim of this module is to enable students to manipulate simple inexpensive equipment to actively construct a conceptual understanding of the concepts related to balance. The use of Maldivian examples and context proposes to provide the links between the science classroom and the everyday-life of the students.

This approach to teaching sees the student as one who uses the resources available (the teacher and the equipment) to construct his/her own meaning of the concept. The teacher's role is that of a facilitator and is required to provide help when required.

LESSON 1

INTRODUCTION

Note to the teacher:

The first 15 minutes of this lesson should be spent:

(a) creating the rules to be observed during science lessons-Students generally behave more responsibly if they are involved in making the rules.

(b) organising students into groups of four- The choice of group members should be left to the students as much as possible to ensure positive working atmospheres. Rearrangement of desks is also a possibility.

(c) establishing routines for the distribution and collection of equipment- Students should be involved in the decision-making to establish the sort of responsible behaviour to be expected.

Once the above mentioned tasks have been completed the rest of the lesson may be devoted to introducing the concept of balance through class discussions and demonstrations.

The purpose of this lesson is to help students thinking about the concept of balance and to practice their skills of observation, inference and hypothesising. The following lesson gives examples of balancing and demonstrations as well as "probes" that can be used to introduce the concept through inquiry.

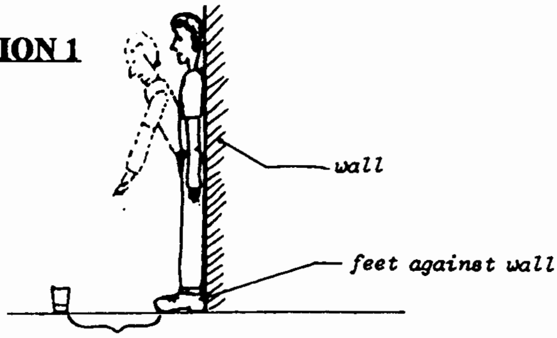
INTRODUCTION TO BALANCE

Crossing a puddle of water by using stepping stones requires concentration to keep your balance (if you do not want to end up in the puddle!). It is easier to keep your balance by using your hands to shift your weight. As long as your weight is **balanced** you are safe from falling. But, if you lose your stability and become **imbalanced** you will probably end up with wet shoes.

Similarly, a soccer ball balanced on the tip of your finger is **stable** until it starts to fall. It regains it's balance when it reaches the ground.

Think of a time when you had to balance some object. Were you able to maintain it? How would you have made the balancing of the object easier?

DEMONSTRATION 1



QUESTION: Can we pick up a pencil from the floor without losing our balance?

Procedure:

1. Place a cup or pop can about 20-30 cm in front of your feet on the floor and show how easy it is to pick it up without moving or bending your feet.
2. Let someone (student) stand straight with the back against the wall with his/her heels touching the wall.
3. Place a cup or pop can about 20-30 cm away in front of the student's feet on the floor.
4. Let the student pick up the cup from the floor without bending the knees and without falling forwards. Is it possible?

(Get different students to try it).

QUESTIONS: (i) What makes it so difficult to pick the pencil up?

(ii) Why do we fall when we try to bend forward?

(Initiate discussion on variables that could affect it - for example, do people with different heights find it as difficult? etc..)

(iii) Does it make any difference if our back is not against the wall? Try it when the pencil is

- 5cm away from the tip of the toes and
- 50cm away from the tip of the toes.

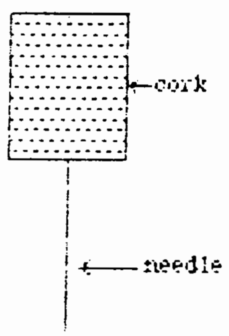
(Initiate discussion of the stability of both instances).

EXPLANATION: When picking up the pencil from the floor without bending the knees, the lower part of the body has to move backwards to ensure that the centre of gravity of the body is above the feet.

When the back is against the wall, the forward bending of the upper body causes the centre of gravity of the body to shift away from the feet of the individual, toppling the body forward.

DEMONSTRATION 2

Can we balance a cork on a needle?

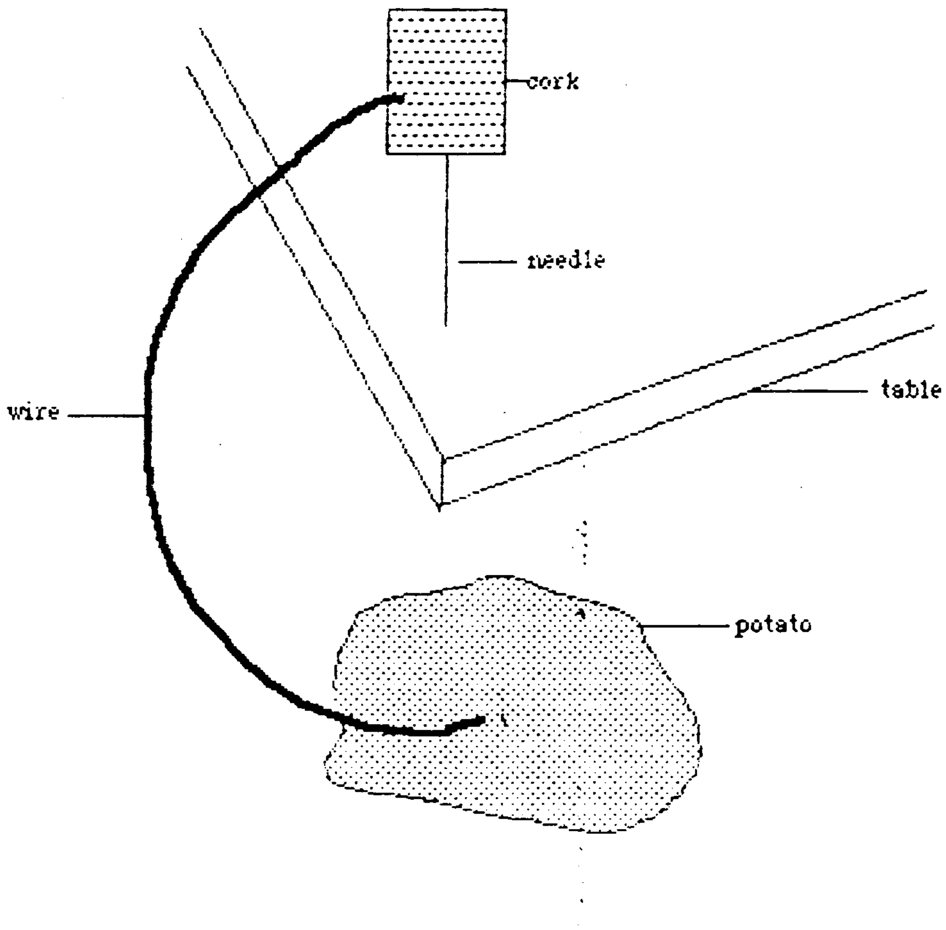


(Get students to attempt it)

QUESTION: Can we use a potato and some wire to make it balance better?

(Ask for different suggestions and get other students to discuss the feasibility of these suggestions. **It is important that judgements about the suggestions are not made by the teacher.** Try the suggestions out and discuss the stability of the object).

Try the following arrangement. Make sure that the potato is directly under the needle.



QUESTION: Does it balance now? Why ?

(Discuss the possible explanations put forward by the student.)

EXPLANATION: The device has a centre of gravity near the heaviest part - the potato- and stands up when it's centre of gravity is under it's point of support.

QUESTION: **What happens if we shift the potato?**

(Invite predictions before trying it out. Discuss.)

Conclude the lesson by recapping the two demonstrations through students' accounts.

LESSON TWO

DESIGNING A MODEL

Note to the teacher

In this lesson students will design a model. The role of the teacher is to
- clarify the task
- ensure that domination of group members do not take place
- make sure that each group hands in a plan at the end of the lesson.

At the end of the lesson, the teacher should make a list of all the items outlined by the groups and ensure that these items are available for the following lesson.

Through the designing activity, the students will be compelled to examine their existing conceptions related to balance. This will make it easier for changes to be made to these concepts.

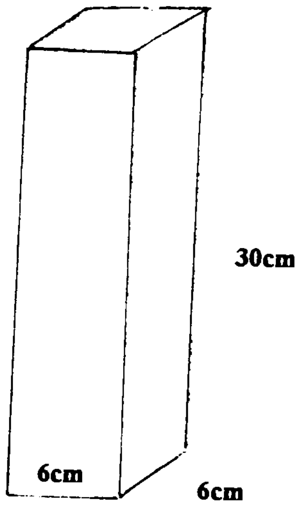
DESIGNING A MODEL

Problem:

"Dhivehi Bahaa Sagaafathah Khidhmaiy Kuraa Marukazu" is planning to construct a monument in memory of the Maldivians who were killed on Shaheedhunge Dhuvas. In this lesson your group will design a model for this monument.

Requirements:

(1) The model should be able to fit into the box shown below.



(2) It has to be as stable as you can make it.

(3) It has to portray the nature of the occasion (BE CREATIVE!)

(4) The materials that you may use in the building are:

- 30 pieces of coral,
- 20 twigs (2 cm long),
- 1 empty box of matches,
- sticky tape,
- thread,
- a piece of wood for the base,
- paper and
- crayons.

Remember to keep this in mind when designing your model.

At the end of the lesson your group will be required to hand in

- **a plan for your model and**
- **a list of what you will need.**

LESSON THREE

IS IT REALLY STABLE?

For the teacher:

This lesson will be spent building the model. The students will evaluate their models on how stable it is. The aim of this lesson is to encourage students to contest their pre-existing concepts related to balance by using the model they built.

After they build their model spend a few minutes discussing problems faced by each group when trying to build a stable monument. Discuss possible solutions to these problems. Elect the best model for the monument on the basis of

- stability and
- creativity .

IS IT REALLY STABLE

In this lesson, you will make the model that you have designed for the monument. Make sure that you follow your plan.

Did you have any problems in building your model? If you did, note them down

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(a) How can you test it's stability ?

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(b) Use your test of stability on the model. What happened? Why?

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(c) How can you increase it's stability? discuss and write down what you can do.

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(d) You are given 10 more pieces of coral to increase the height of your structure as much as possible. How would you modify the model? Plan, then try it out.

Check it's stability. How does it's stability compare to the original model's?

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(e) How did you try to maintain it's stability?

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The most interesting and stable model will be chosen to be sent to the Marukazu. Elect a presenter for your group. Discuss how he will present your model . Remember to discuss how you increased or maintained the stability and how well it represents Shaheedhunge Dhuvas.

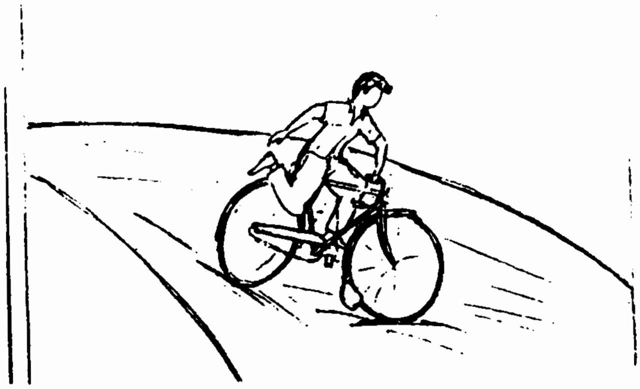
LESSON FOUR

To the teacher:

The purpose of this lesson is to increase students' understanding of the concept of centre of gravity. Stability of objects is addressed in association with centre of gravity and the role of the base of the objects.

The lesson is activity-based and encourages peer teaching through group work. The teacher might provide some useful background by providing examples found in students' environment (ie Maldivian examples).

WHY DO OBJECTS FALL OVER?



Why do you fall off your bicycle if you lean too far over to one side?

Why is it more difficult to balance on a bicycle with ***narrow*** tyres than one with ***wide*** tyres?

FIND OUT!

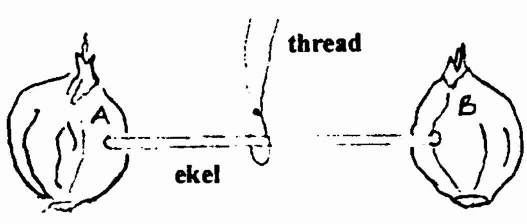
You will need:

- 1 piece of ekel (20 cm long)
- 1 piece of thread (10 cm long)
- 2 small onions
- 1 felt pen or marker
- 1 potato
- 1 clove of garlic
- 1 lemon
- 1 pin

Try this:

PART A

(1) Stick two onions on both ends of the ekel. Label the onions A & B. Tie the thread around the ekel loosely, as shown in the diagram.



(2) Lift the "dumb bell" using the thread. What happens?

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3) Position the loop at different points on the ekel. Lift the dumb bell each time. Note the difference (if there is any) in the way the dumb bell balances. Discuss and suggest possible reasons for this.

(4) What happens when the thread is near onion A? Why?

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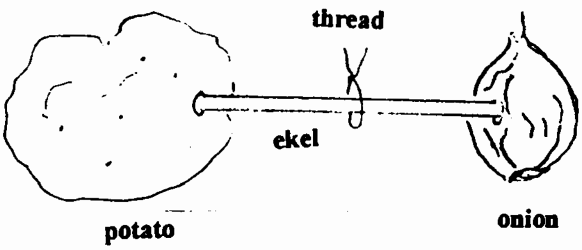
(5) Replace onion A with the potato as shown in the diagram. Find the point of balance of the new "dumb bell".



THE POINT OF BALANCE OF AN OBJECT IS CALLED IT'S ***CENTRE OF GRAVITY***

(6) Is this "dumb bell" more stable than the first one? Why?

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(7) Discuss how you can test it's stability. Try it.

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(8) Use the following objects to make different "dumb bells".

1 clove of garlic,
1 lemon,
1 potato and
the original "dumb bell".

Compare the positions of the centre of gravity on the ekel for the different "dumb bells".

(9) Describe in your own words, how the **centre of gravity** of a person might be determined by looking at him/her.

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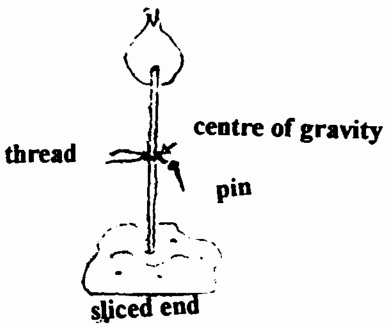
PART B

(1) Make the "dumb bell" shown in the diagram below. Remember to slice off one end of the potato. Find the centre of gravity of the "dumb bell".Knot a pin to a piece of thread and tie it to the point of balance as shown in the diagram. Stand the "dumb bell" as shown.



(2) Gradually tilt the onion end of the "dumb bell". When does it fall over? Try tilting it to the other side. Explain to your group why objects fall over.Write down your explanation.

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LESSON FIVE

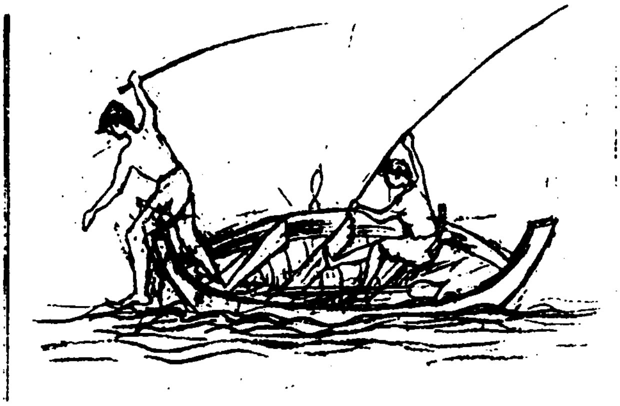
To the teacher:

This lesson is aimed at providing a contrived set of experiences for the learner to "discover" the law of balance. Therefore, it is extremely important that students' be given enough time to discuss their views within their groups and to try different ways of balancing the ruler.

If, at the end of task (5), the students have not "discovered" the rule, the teacher should direct the class discussion to obtain the rule of balance through student responses.

THE RULE OF BALANCE

What happens when you jump into one end of a small empty *bokkuraa*? What do you do while you are trying to balance the bokkuraa to make sure you don't turn it over?



In groups you will now find out how the bokkuraa is balanced and the law which shows you where to sit in it to make sure that it doesn't sink.

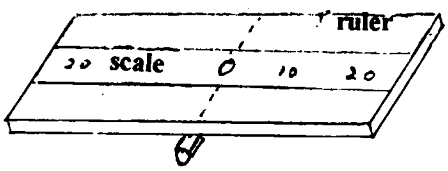
INVESTIGATING THE LAW OF BALANCE

Each group will need:

- 1 wooden ruler
- 1 paper scale (drawn on graph paper)
- 1 roll of sticky tape
- 1 pencil
- 14 wooden washers
- some clay
- 1 record sheet

Instructions

(1) Tape the paper scale onto the wooden ruler as shown.



(2) Balance the ruler on the pencil so that the "0" on the scale is right on top of the pencil.

(a) Did your ruler balance?
(If the ruler does not balance put some clay on one end until it balances.)

(b) Using the results from (3) discuss where the centre of gravity of your ruler lies.

(c) What does this mean about the weight in the different parts of the ruler?

Discuss the above questions within your groups

BREAK!!
 # TEACHER - CENTRED DISCUSSION#

(3) Place one wooden washer on the "10" mark on one side of the ruler. Make sure that the centre of the washer is directly on top of the mark.Observe. Place another washer on the "10" mark on the other side of the ruler. What happened?

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(4) Carry out the following tasks and observe what happens

	Right-hand side	Left-hand side
(a)	1 washer on "10"	1 washer on "9"
(b)	1 washer on "10"	1 washer on "11"
(c)	1 washer on "10"	2 washers on "5"

Discuss reasons for your results within your groups.

(5) Try the following combinations to see if you can come up with the rule of balance.

	Right-hand side	Left-hand side
(a)	4 washers on "3"	3 washers on "4"
(b)	1 washer on "6"	2 washers on "3"
(c)	1 washer on "10"	2 washers on "5"

Do you know what the rule is now?
Use your record sheet and discuss among the group what the rule can be.

BREAK! CLASS DISCUSSION!

(6) Find two other ways to balance the ruler by placing different amounts of washers at different positions. Write them down.
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RECORD SHEET

Left hand side		Right hand side	
Number of washers	**Distance from centre**	**Number of washers**	**Distance from centre**

THE RULE OF BALANCE

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(7) Try half-distances. Does the law still apply? Write down the rule you found.

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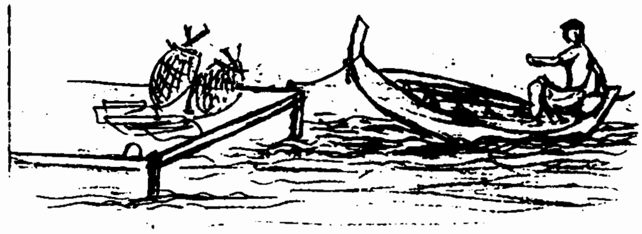
(8) Use the law of balance to explain how you would balance the dhoani in the picture below.



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LESSON SIX

HELICOPTERS

To the teacher:

In this lesson, students will investigate the effect of imbalance - ***rotation.*** The concept of rotation will be introduced by flying "helicopters". This holistic approach attempts to increase students' awareness about the complex nature of the action of such forces in real life.

This lesson also introduces students to controlling variables by using comparisions.

HELICOPTERS

Up to now you have looked at balancing and how to stop objects from toppling over and turning. Sometimes the motion of turning is quite useful and necessary.

For example: When removing the cap on a bottle a turning force is applied.

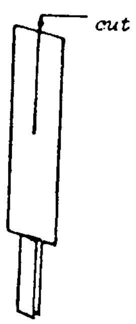
We have also often observed leaves turning and twirling around in the wind. How does the wind make them twirl?

In this lesson we will look ,at how objects can be made to turn.

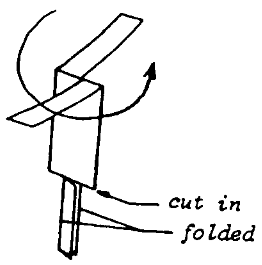
You will need:

3 strips of paper (about 15cm long and 5cm wide).
a pair of small scissors.

Instructions:



Sketch A



Sketch B

(1) Take the paper strip and cut about 5cm into the centre of the strip. Fold the two parts to opposite sidesof the strip (see sketch A).

(2) At about 5cm from the other end of the strip, cut crosswise one third into the width of the strip and fold the two parts on top of each other, making the bottom part thicker (see sketch B).

(3) Take the "helicopter" by holding onto the middle and drop it to the floor from standing height. What happens to the piece of paper as it falls down? Write down your observations. Note the direction of the motion.

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(4) Discuss within your group what would happen if you folded the wings in the opposite direction. Try it! Were your predictions true? Explain.

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(5) Make a second helicopter (Heli-2) using the second piece of paper. Shorten the wings by making the cut in the centre of the strip 3cm. Fly both helicopters from the same height together. What is the difference in their flight?

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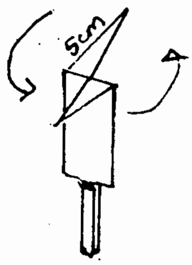
(6) Make Heli-3 as shown in the diagram.



Compare the following flights.

(a) Heli-1 and Heli-3

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(b) Heli-2 and Heli-3

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(7) On the basis of your investigations, explain how objects can be turned

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LESSON SEVEN

ROTATION

To the teacher:

In this lesson, the demonstrations and class discussions are planned to present the concept

$$\text{Torque} = \text{Force} \times \text{Distance}$$

by an activity where the students try to rotate a table. The idea of two small forces being used to bring about the same rotation is also introduced.

As this is the last lesson of the module, the teacher should provide an overview of the module (possibly through student accounts as this will increase retention of what was learnt and also provide an opportunity to modify misconceptions.

ROTATION

What makes objects turn?

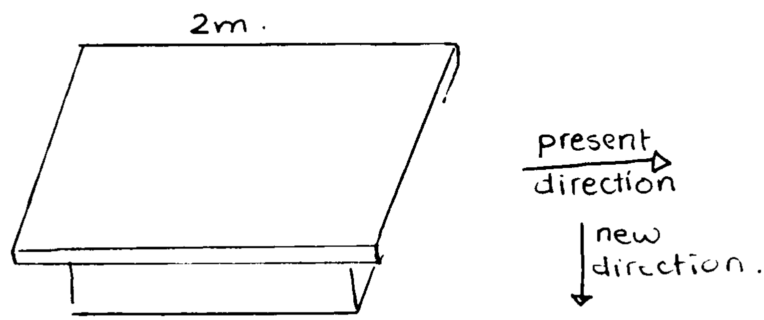
Imagine that you are doing the following:

(a) opening a tap,
(b) winding a toy and
(c) turning a table around by lifting one end.

THINK! WHAT IS THE SAME FOR ALL THESE EXAMPLES?

Problem:

Hassan's maama has a big 2m long "ashi" in her house. She wants it rotated until it is *perpendicular* to it's original position



If Hassan and his friend Samih tried to rotate it how would they turn it?

(Ask students to describe the event. Try it out using role play. Use white chalk to trace their paths.).

However, Samih did not drop in that afternoon. So poor Hassan had to do it on his own.

(Invite "Hassan" from the previous role play to rotate it by

(a)- lifting one end of the "ashi" and rotating it.
(b) - lifting the table in the middle and rotating it.

Use a different coloured chalk to trace his path.)

Compare the amount of work done by "Hassan" in (a) and (b) by questioning "Hassan" on the ease with which the rotation is carried out.

DIRECT THE CLASS DISCUSSION, SO THAT

ROTATION = FORCE × DISTANCE
(TORQUE)

IS UNDERSTOOD.

Contrast the amount of work done by "Hassan" in (a) and if he and Samih had turned the table.

INTRODUCE THE CONCEPT OF COUPLES; EMPHASISE THE FACT THAT TWO SMALLER OPPOSITE FORCES ACTING ON THE OBJECT CAN PRODUCE THE SAME MOVEMENT AS IN (a).

Discuss the relative advantages of the different methods of rotating objects.

RECAP THE MODULE THROUGH CLASS DISCUSSION

Appendix B

Checklists used for the verification of the teaching approaches

CLASSROOM OBSERVATION SHEET

1. LESSON NO.	1 + 2			
2. TEACHING APPROACH	INQUIRY			
3. TIME ALLOCATION	7:00 to 8:00			
4. IMPLEMENTATION OF THE LESSON	a. Did the teacher use the said approach?	all the time	[✓][ ][ ][ ][ ]	never
	b. How well did the teacher use the approach?	very well	[✓][ ][ ][ ][ ]	poorly
	c. Did the students take part in any activity?	all the time	[✓][ ][ ][ ][ ]	never
	d. Was information given to the students?	all the time	[✓][ ][ ][ ][ ]	never
5. STUDENT INVOLVEMENT	a. Did the students know what was expected of them?	all the time	[✓][ ][ ][ ][ ]	never
	b. Were the students on task ?	all the time	[✓][ ][ ][ ][ ]	never
5. CLASSROOM MANAGEMENT	a. Did the teacher have to interrupt the lesson to bring students back on task?	all the time	[ ][ ][ ][ ][✓]	never

CLASSROOM OBSERVATION SHEET

1. LESSON NO.	3 & 4	
2. TEACHING APPROACH	INQUIRY	
3. TIME ALLOCATION	8:00 to 9:00	
4. IMPLEMENTATION OF THE LESSON	a. Did the teacher use the said approach?	all the time ☑ ☐ ☐ ☐ ☐ never
	b. How well did the teacher use the approach?	very well ☑ ☐ ☐ ☐ ☐ poorly
	c. Did the students take part in any activity?	all the time ☑ ☐ ☐ ☐ ☐ never
	d. Was information given to the students?	all the time ☑ ☐ ☐ ☐ ☐ never
5. STUDENT INVOLVEMENT	a. Did the students know what was expected of them?	all the time ☑ ☐ ☐ ☐ ☐ never
	b. Were the students on task ?	all the time ☑ ☐ ☐ ☐ ☐ never
5. CLASSROOM MANAGEMENT	a. Did the teacher have to interrupt the lesson to bring students back on task?	all the time ☐ ☐ ☐ ☐ ☑ never

CLASSROOM OBSERVATION SHEET

1. LESSON NO.	1								
2. TEACHING APPROACH	TRADITIONAL								
3. TIME ALLOCATION	7:00 to 7:30								
4. IMPLEMENTATION OF THE LESSON	a. Did the teacher use the said approach?	all the time	✓					never
	b. How well did the teacher use the approach?	very well	✓					poorly
	c. Did the student take part in any activity?	all the time					✓	never
	d. Was information given to the students?	all the time	✓					never
5. STUDENT INVOLVEMENT	a. Did the students know what was expected of them?	all the time	✓					never
	b. Were the students on task ?	all the time					✓	never
5. CLASSROOM MANAGEMENT	a. Did the teacher have to interrupt the lesson to bring students back on task?	all the time					✓	never

Meaning they were doing a task?

Classroom Observation Sheet

1. LESSON NO.	2							
2. TEACHING APPROACH	TRADITIONAL							
3. TIME ALLOCATION	7:00 to 7:30							
4. IMPLEMENTATION OF THE LESSON	a. Did the teacher use the said approach?	all the time	✓					never
	b. How well did the teacher use the approach?	very well	✓					poorly
	c. Did the student take part in any activity?	all the time					✓	never
	d. Was information given to the students?	all the time	✓					never
5. STUDENT INVOLVEMENT	a. Did the students know what was expected of them?	all the time	✓					never
	b. Were the students on task ?	all the time					✓	never
5. CLASSROOM MANAGEMENT	a. Did the teacher have to interrupt the lesson to bring students back on task?	all the time					✓	never

CLASSROOM OBSERVATION SHEET

1. LESSON NO.	3+4	
2. TEACHING APPROACH	TRADITIONAL	
3. TIME ALLOCATION	7.00 to 8.00	
4. IMPLEMENTATION OF THE LESSON	a. Did the teacher use the said approach?	all the time [✓][ ][ ][ ][ ] never
	b. How well did the teacher use the approach?	very well [ ][✓][ ][ ][ ] poorly
	c. Did the students take part in any activity?	all the time [ ][ ][ ][ ][✓] never
	d. Was information given to the students?	all the time [✓][ ][ ][ ][ ] never
5. STUDENT INVOLVEMENT	a. Did the students know what was expected of them?	all the time [✓][ ][ ][ ][ ] never
	b. Were the students on task ?	all the time [ ][ ][ ][ ][✓] never
5. CLASSROOM MANAGEMENT	a. Did the teacher have to interrupt the lesson to bring students back on task?	all the time [ ][ ][ ][ ][✓] never

Appendix C

The relevant sections of the Grade Eight Physics Foundation Course

Detailed Schemes

and

Syllabuses for Grade 8 foundation course

INTRODUCTION

Changes were occurring both within the syllabus itself and due to the wide gap between grade seven 'Science' and grade eight 'Physics'. This offered fertile ground for the members of the Physics Teacher's Committee drawn from a wide spectrum of educational experience, to create a curriculum model to meet the demand of a 'foundation course' in Physics at grade eight level

2. FORMAT OF THE SCHEMES OF WORK.

A graduated approach has been adopted in planning the schemes of the foundation course which will ease the transition from 'broad and balanced' science at junior secondary level to the narrower and more demanding in-depth style 'O' -level Physics.

2.1 Each scheme of work is set out in four columns. In the first column, the time allocated is indicated. Teachers are requested to re-examine their instructions to see whether he/she is devoting too much time because of his/her interest/ familiarity with it or other reasons. Teachers are expected to explore the possibility of saving time by arranging certain demonstrations during pupil's work sessions, which the class can observe when they have completed their work. This is a fruitful source of time saving. Teachers are expected to find time for their unit tests, monthly tests etc.

2.3 The main topics and sub topics are listed under the content area in the second column.

2.4 The main outcomes expected from teaching [objectives] are given in column 3. The various objectives, amongst themselves,have very different status. Some are merely significant observations, others state an experimental generalization, a hypothesis, theoretical concept or a descriptive nature of an experiment. There are, among them, indications of skills to be acquired, both of simple manipulation or ratiocination.

2.5 The methodology in terms of suggested relevant teaching outline is given in column 4. The methodology is not presented in terms of detailed teaching procedures or discussions, teacher demonstrations, student's practical work and other activities. Notes are provided briefly to supplement information given in this column. By taking the skills of an individual teacher into consideration, reservations have been left to develop his/her own methods to suit the pupil best.

2.6 Methods of evaluation are not indicated in a separate column in the scheme. It is suggested that oral questions,short answer questions should be set to cover the topic during the week. Short answer questions provide the easiest means of assessment.
The questions themselves may be of many different types. For example, structured type questions, fill in the blanks type, long written questions to test their reaction to teaching and individual performance. questions designed and improved in elegance and scope,with experience, questions merely to demand the recall of a piece of teaching for example, rules, laws,conditions of validity etc. Essay type questions should be set less frequently and they must be set with care. These questions should be set to test the pupil's knowledge in a rather wide area of the subject.

3. GENERAL NOTES ON PRESENTATION OF SUBJECT MATTER.

3.1 **The prime objective in teaching physics is to stimulate the kind of thinking by** pupils necessary to developing scientific method
To establish and maintain pupil's interest in a topic cannot be realised satisfactorily when the teacher merely recites the subject matter or states the *outcomes to the class.*
There need to be a move away from the standard procedure of giving/making notes,simple problem solving exercises, examination questions towards more varied range of learning experiences. We need to look at the schemes and see where we can fit in things such as 'field work', practical work(both in school and at home.), group work, essay writing, role play, quiz words, cross words, mix and match exercises, true-false exercises, film/slide shows, discussions and debates It is easier to remember concepts in physics when students have learnt them *through first hand experiences.*

3.2 The applications we use to introduce a new concept should be local and familiar to all the students. It is much easier to understand concepts when **they** *see things happen, rather than have them described to them*
Because of the type of examples that are usually presented, there is a tend**ency** to regard physics as a 'boy's subject'. Teachers handling female students should remember to pick examples relevant to student's everyday experiences and find more 'girl-friendly' examples. Topics in which there are many **everyday** examples and rich in applications include energy,heat,light,circuit-electricity, electromagnetism and waves.

3.3 Taking the practical nature of the subject into consideration, make special effort in introducing student investigations, practical tasks of an open-ended nature that promotes designing, experimental technique and data handling. Special interest must be taken in promoting skill-based learning such *as planning, observation,recording,sequencing information,data handling,* **processing information,data interpretation,graph work,predicting and** hypothesizing etc.

3.4 Carefully selected examination - style questions, work sheets to test theory and applications of physics in **everyday contexts,extension material to help more advanced students,monitoring their degree of independent learning,investigation,** and the ability of reasoning carry long way in improving the quality of **teaching** physics and active learning. It is more interesting to find things rather than to be *told correct answers. Studying physics is an art that can acquire by practice*

4.0 However it is recognized that there are difficulties in teaching physics with some schools. Some of these problems may be outlined as follows.

- ***Lack of laboratory facilities in the school.***
- Insufficient quantity/number of material/equipment available for group work.
- Limited number of periods allocated for the use of the school laboratory per each class.
- Lack of services of laboratory assistants.
- Poor understanding of the medium of instruction.
- Too many things to cover in a specified time limit.
- Class size
- *Lack of time to plan lessons in detail*

5.0 Possible solutions to these problems may be listed as follows

- Use of science kits, improvised equipment, locally available equipment, get children to bring things in, do investigations at home and make use of the local environment
- Teacher demonstrations.
- Make arrangements in advance to conduct practicals in the class room.
- Use pictures/illustrations, conduct more practical work/demonstrations, allow children to discuss work in groups, use Dhivehi language to explain things, promote language reinforcement activities to ease the difficulties related to poor understanding of the language.
- Set realistic goals, select activities which are appropriate to the lesson, plan in advance what is expected to be covered.
- Prepare work sheets for your practical work and distribute among children prior to the practical class. Make sure that all you need for the group work are kept aside in advance.
- Make use of a teacher's guide, if there is any, available in the school.

6. Guidelines for learning and teaching such as these schemes provide are never appropriately described by the words 'perfect' and 'final'. They must always be provisional and liable to revision. Infact periodical reports directed towards revision of these schemes may be requested in due course. Co-operation of teachers in using these schemes and their assistance in such revision is earnestly solicited.
The preparation of provisional schemes is a relatively long and tedious task. It is hoped that these schemes will contribute significantly to teaching physics for the secondary school students. The test of all teaching must be in the quality of the learning, and the proof of these resources will be in the understanding and ease of accessibility which they generate.

(*Term 01 scheme was done by Mr. S. Thadchinamoorthi of Majeediyya School.* Schemes of work for both term 02 and 03 were prepared by Mr. Gamini W. Siriwardena of Majeediyya School, Male'. Editing of the texts and typing are also done by Mr. Siriwardena.)

8&9	3.00 FORCES II		
	3.01 Turning effect of a force.	3.01 state practical examples of the turning effect of a force.	Discuss examples such as opening a door by the handle,using a spanner to loosen a nut When the handle is near the hinge, a large force is needed. Show that it is easier to loosen a nut with a long spanner than one with a short length.
	3.02 The moment of a force.	3.02 know and understand that the moment of a foce about a point as the magnitude of the force multi-plied by the perpendicular distance between the two.	Explain that the turning effect or moment force depends on both the size of the force and how far it is applied from the pivot or Define moment of a force = force x perpendic distance of the line of action of the force from the point.
	3.03 The moment of a couple.	3.03 know that two equal and parallel forces opposite to one another and not acting at a point cause rotation.	Demonstate and explain that two equal an opposite forces form a couple and cause rotation. Steer a bicycle round a bend with both hands on the handle bars. Explain the action of a water sprinkler.
		3.04 understand that the moment of a couple is the product of one of the forces and the perpendicular distance between the two.	Show that the moment of a couple [torque is the product of one of the forces and the perpendicular distance between the two.

10	3.04 Centre of gravity		
		3.05 know and understand that an object behaves as if its whole weight were concentratedat its centre of gravity [centre of mass]	Explain that the weight of a body acts at its centre of gravity. Show that a uniform beam can be balanced on a knife edge placed at its geometrical mid point.
	3.05Principle of moments	3.06 understand clock-wise and anti-clockwise moments and that the sum of the clockwise moments of a set of forces parallel to each other acting about a point equals to the sum of anti-clockwise moments about the same point.	Describe and demonstrate an experiment to verify that when a body is in equilibrium the sum of the anti-clockwise moments about any point equals the sum of the clockwise moments about the same point.
		3.07 use the principle of moments to solve problems involving simple systems of parallel forces acting in one plane.	
	3.06 Conditions for equili-brium, when number of parallel forces act on it.	3.08 know the two conditions for equillibrium of a body under a set of parallel forces and use these two conditions to solve problems.	Explain that an object stays in equillibrium only when i) the sum of the forces in one direction equals the sum of the forces in the opposite direction ii) the sum of the clockwise moments about any point equals the sum of the anti-clockw moments about the same point.

THE END OF TERM 02

Appendix D

The Achievement Test

BALANCE

END OF MODULE TEST

Time: 30 minutes

Read **ALL** the questions carefully. If you don't understand any of the words, please ask the teacher for help.

Answer **ALL** questions as fully as possible, on this paper.

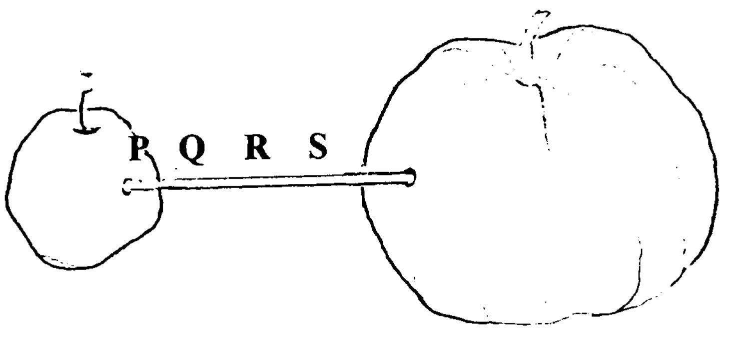
To answer the multiple choice questions, circle the correct answer.

All calculations need to be shown for the short answer questions.

BALANCE

END OF MODULE TEST

1. The following diagram shows a toy dumb bell made from a small pumpkin and a kunnaaru.



The centre of gravity of this object would be at

(a) P
(b) Q
(c) R
(d) S

2. What is the rule of balance?

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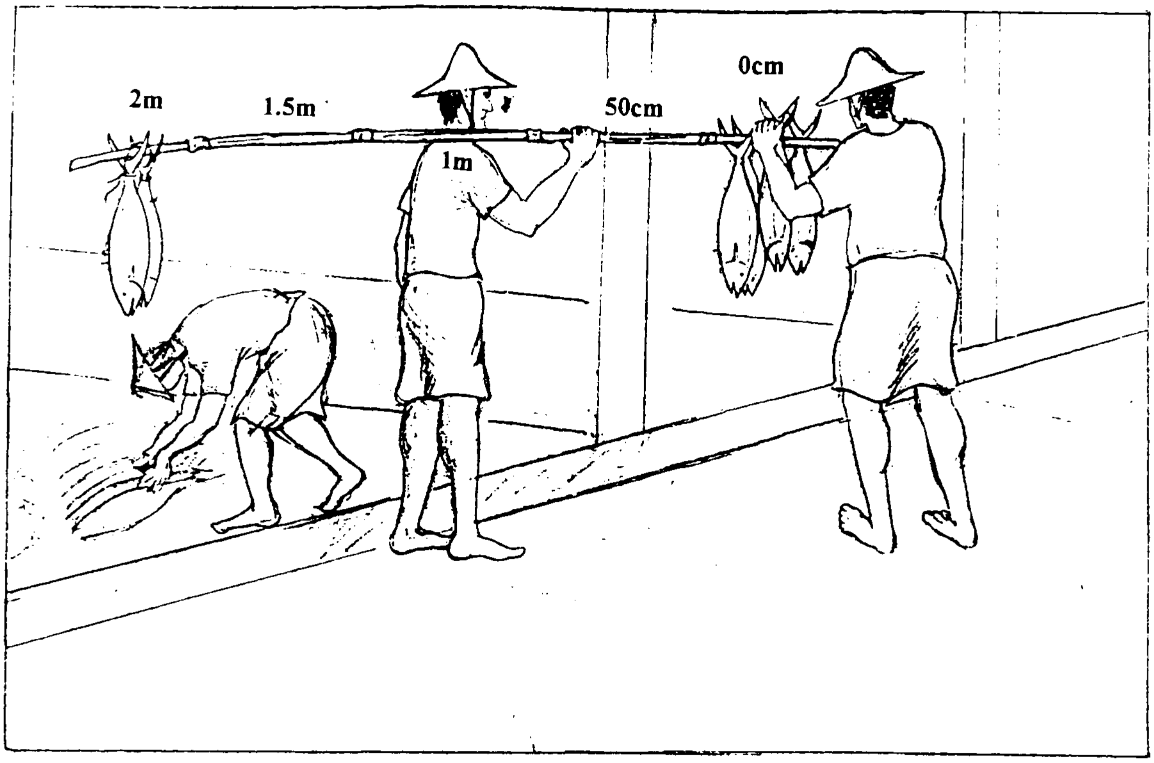
3. Yoosuf took a light, 2 m pole to carry tuna home from the market. He bought six tuna weighing 1 kg each. (Assume that the weight of the pole is negligible).



For his journey home, he decided to tie two tuna to one end of the pole. If he wants to position the midpoint of the pole on his shoulder, he has to tie the remaining four tuna

(a) at the other end

(b) 25 cm away from the other end

(c) 50 cm away from the other end

(d) 75 cm away from the other end

of the pole in order to balance it.

4. When he reached home his sons, Shafiu and Sameer untied one tuna from either end of the pole. How does this affect the balance of the pole? Explain.

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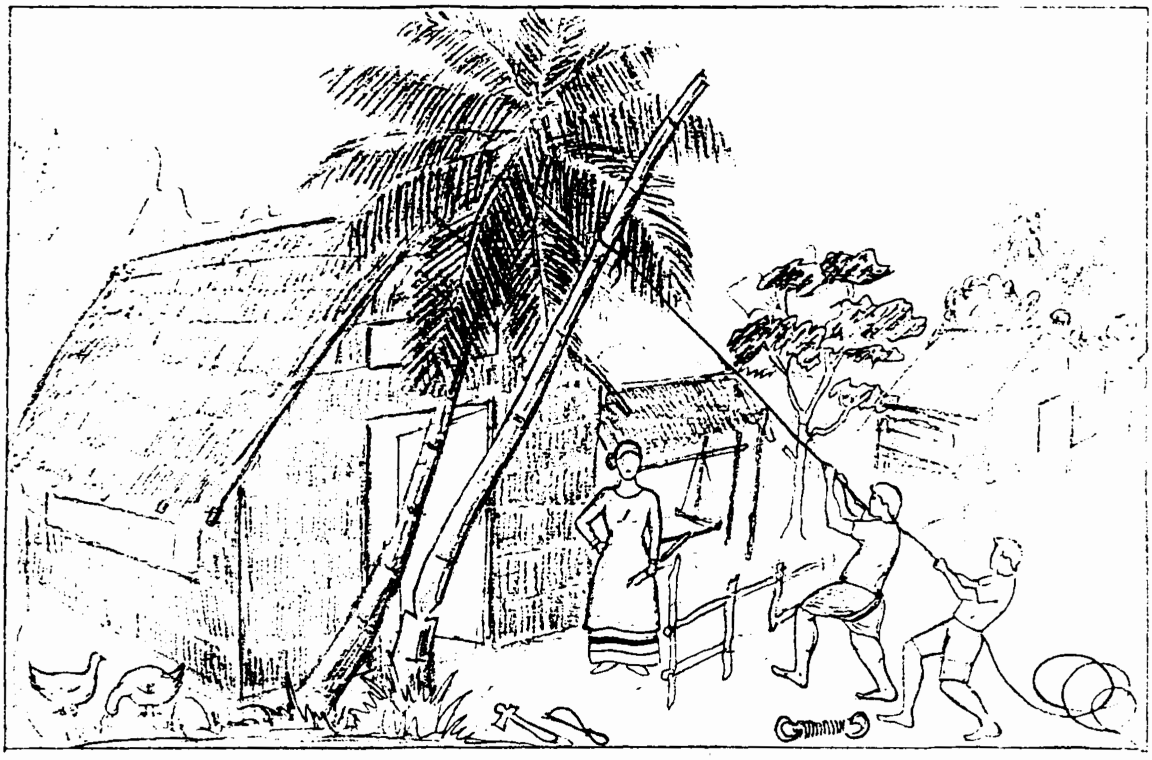
5. Shafeega hired Easa and Yaqoob to cut down the coconut palm next to her house. She cautioned them to be careful as she did not want any damage done to her house. The following diagram shows how they went about the task.



Yaqoob, argued that it would be easier to pull the tree down with the coconuts still on it.

Would you agree? Why?

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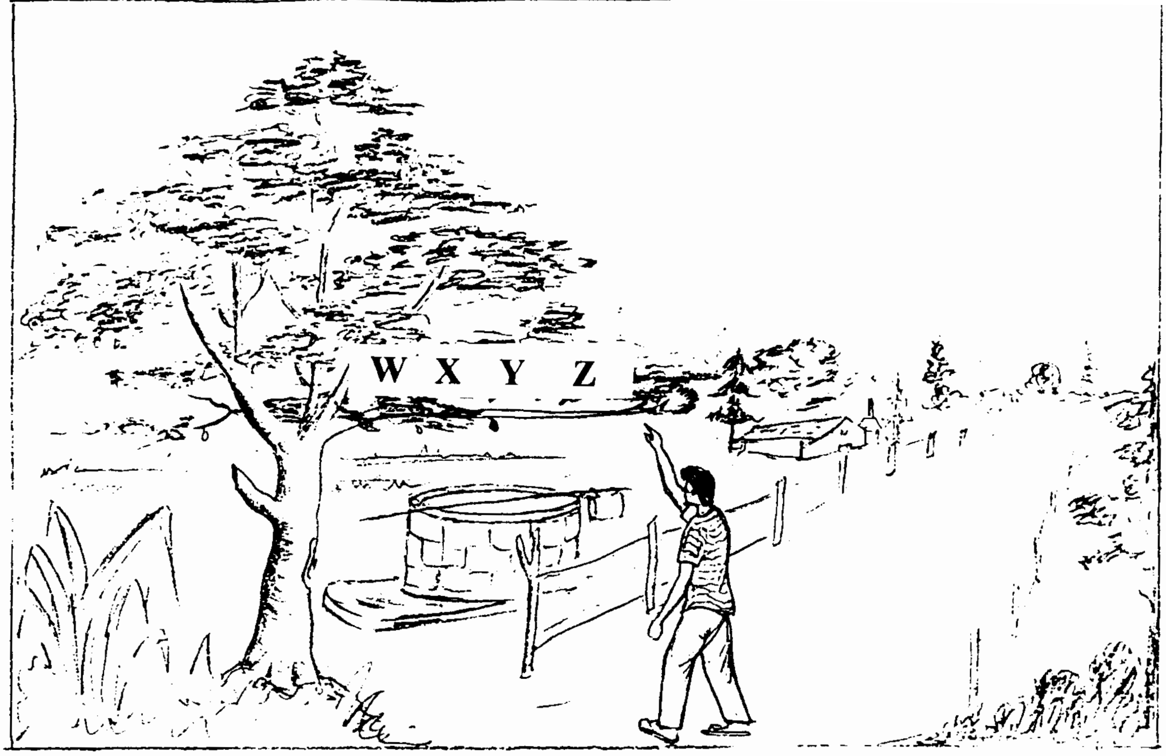
6. Chopping around the base of the tree before pulling it down makes the tree easier to fell because

(a) the weight of the tree is reduced.

(b) the centre of gravity shifts towards the base.

(c) the centre of gravity falls outside the base easily.

(d) gravity pulls the tree down faster when the area of the base has been reduced.



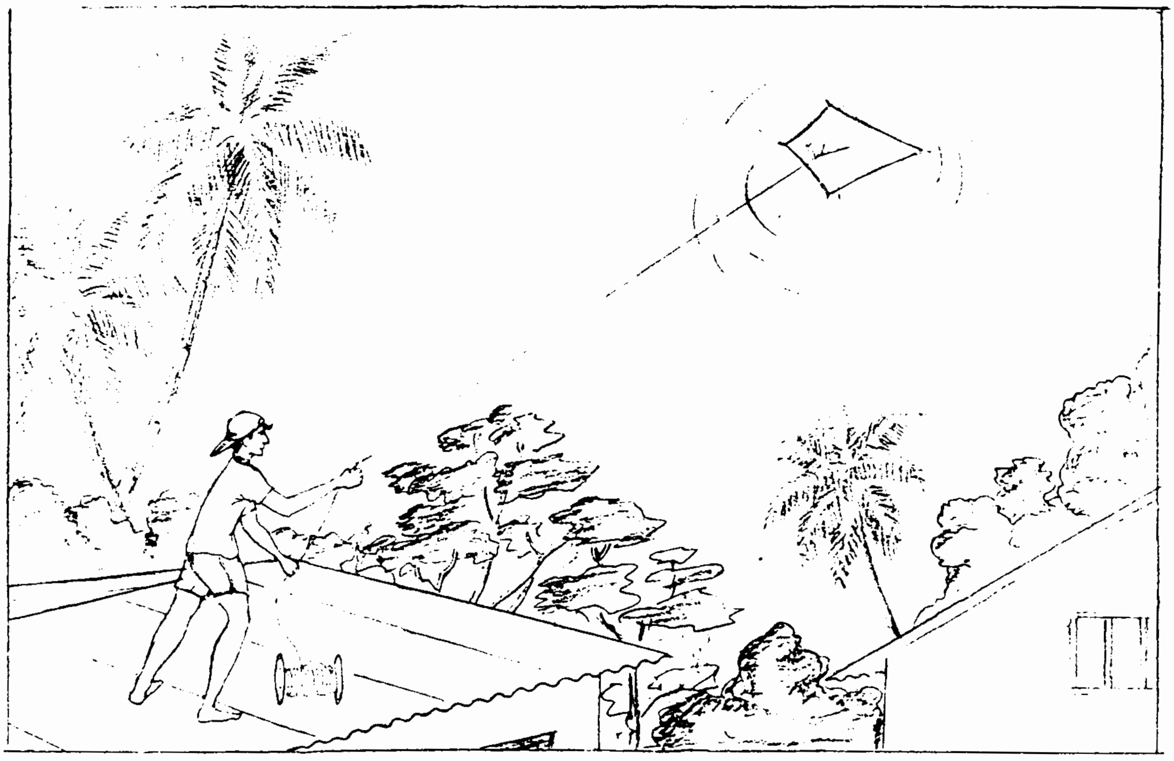
Shiyam saw a delicious, ripe, jeymu on a tree in his garden. However, the jeymu was too high up for him to reach. He decided to pull the branch down so that he could pick it. It would be easier to pull the branch down by holding it at

(a) W

(b) X

(c) Y

(d) Z



Zeine made a kite for the first time. To his dismay, he found that when he tried to fly it, it kept going round and round. Using the concept of balance, explain to him why his kite is not flying perfectly.

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9. Describe to him how he can modify the kite to make it fly better.

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Now go back and check your answers!

END

Appendix E

The Attitude Test

STUDENT ATTITUDE TEST

PURPOSE:

The purpose of this questionare is to find out your thoughts or feelings toward the science lessons that you have had in the past two weeks.

Please respond to all the statements honestly and to the best of your ability. Your answers are confidential. THIS IS NOT A TEST.

In this questionare:

SA - stands for strongly agree,
A - stands for agree,
UD - stands for undecided,
D - stands for disagree and
SD - stands for stongly disagree.

INSTRUCTIONS:

1. Read the statement carefully.

2. Pick the word from the scale that **best describes** how you think or feel about the activity in the statement.

3. Put an X in the circle provided. This X shows how strongly you think or feel about the activity in the statement.

Example:

Here is an example of a statement which has been responded to:

I like rainy days.

In this example, the X placed under the DISAGREE shows that the person responding to this statement does not like rainy days.