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THE EFFECT OF A PRIMARY SCHOOL MULTI-MEDIA PACKAGE AND INSTRUCTION ON CONCEPTUAL CHANGE IN PRE-SERVICE TEACHERS

by

SEKGOBOKOANE SHADRACK MAHAPA

A RESEARCH REPORT

in partial fulfilment of the requirements

for the degree of

MASTER OF SCIENCE

(by coursework and research report)

in the

SCHOOL OF SCIENCE EDUCATION

of the

UNIVERSITY OF THE WITWATERSRAND

ABSTRACT

This project is concerned with a multimedia package which incorporates comics, video and pupil workbooks. The intention was to determine the effectiveness of the package on the conceptual change of pre-service teachers, using an empirical research method and descriptive analysis of results. Logistical constraints experienced at colleges of education and schools led to an alternative evaluation of the package with D.E.T. college lecturers at RADMASTE workshop. Results indicated that, if properly administered, the multimedia package can assist users in identifying and changing their interfering preconceptions and misconceptions while they are enjoying the story.

DECLARATION

I declare that this research report is based on my own work, except where otherwise stated. It is being submitted in partial fulfilment of the degree of Master of Science in the School of Science Education of the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any University.

.....

S.S. Mahapa

1995-02-01

DEDICATION

To the memory of my beloved parents, the late

Mr Joseph Kwete Mahapa

and

Mrs Mosima Bernice Mahapa

who have sacrificed much of their time and never compromised their dedication to fulfil their dream of seeing their son through a university degree course.

ACKNOWLEDGEMENTS

I am greatly indebted to my supervisor Mika Stanton for meticulously and tirelessly imparting his expert advice and guidance to me throughout this study, which was carried out during the most difficult moments of the country undergoing political transformations.

I would also like to thank Marissa Rollnick for her expert and scrupulous advice, influences on this work, and for exposing me to the people and organizations which were interested in the science education of primary school pupils.

It would be a mistake if I were to forget to thank all RADMASTE officials for the assistance they have given me with regard to reference material and word processing information.

My thanks should also be directed to the Rector of Mokopane College of Education, Sehlophe Maredi and his staff in the Natural Sciences Department for allowing me to involve their students and use their facilities during the process of this study; the principals of the primary schools and their staff members who have shown a lot of co-operation, unmeasurable interest and particular care to ensure that my work proceeded at their schools without any hinderance; Mundspring Trust for Puppetry in Education for their material and financial support; Mary Anne Bahr and Helena Perold for sharing such a wealth of ideas with me and their support; Bri Carrettoni for tirelessly and meticulously reading through my thesis and correcting the language; Jeremiah Maseko for sharing his indispensable computer and graphics knowledge.

Perhaps my greatest debt is to my life partner Sabina with whom I discussed and argued over certain points, and who has patiently witnessed the trials and tribulations of the birth of this research report.

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GLOSSARY OF TERMS AND ABBREVIATIONS

Terminology

1. *Comic* - A magazine containing an amusing story

2. *Conceptual change* - Changing of originally held ideas on a class of things.

3. *Constructivistic approach* - The approach which sees knowledge as being constructed by the child while the child is developing, and is against the idea of viewing a child as a "blank slate"

4. *Control group* - A group or sample which is kept for later reference. This group is allowed to proceed with its normal activities without interference by the researcher

5. *Diagnostic test* - A test which is introduced to discover the cause or basis of problems experienced by pupils

6. *Experimental group* - A group or sample used by the researcher for experimenting

7. *Geometrical Optics* - The branch of science concerned with vision, sight and light applying the principles of geometry

8. *In-service teacher* - Teachers who are currently in the teaching field

9. *Intervention* - Action which has an effect in a particular situation

10. *Intuitive ideas* - Feelings or ideas for something to exist or appear in a particular way without evidence, proof or explanation

11. *Key concepts* - Main ideas or principles which relate to a particular view in a section of study

12. *Misconceptions* - Wrong ideas which are commonly not consistent with experimental truth but are mostly stable and organized in individual's thinking

13. *Opinionnaire* - Questionnaire which is mainly aimed at gathering the respondents opinions with regard to a specific issue

14. *Pilot materials* - Materials produced for testing whether the initial part of a study will be successful, before it is carried out on a larger scale

15. *Post-test* - Test which normally occurs after intervention in order to see the role played by intervention in a particular situation
16. *Pre-conception* - The concepts or ideas that develop in the child informally before he or she receives formal education
17. *Pre-service teacher* - Student teachers who are still being trained at a college
18. *Pre-test* - Test which is conducted before the sample could be tampered with or influenced
19. *Questionnaire* - A written list of questions to be answered by a number of people to provide information for a report or survey
20. *Rectilinear propagation of light* - The principle which indicates that light travels along straight lines.
21. *Reflection of light* - The process of bouncing light off an interface instead of allowing it to pass through one or more media
22. *Refraction of light* - Bending of light rays at a particular point between media of different optical densities (refractive indices)

Abbreviations

1.	ANC	African National Congress
2.	L1	First Language
3.	L2	Second Language
4.	L3	Third language
5.	MMP	Multimedia Package
6.	NGOs	Non-Governmental Organisations
7.	PSP	Primary Science Programme
8.	PTD	Primary Teachers Diploma
9.	RADMASTE	Research and development in mathematics, science and technology education
10.	SACP	South African Communist Party
11.	SADTU	South African Democratic Teachers Union
12.	SPTD	Senior Primary Teachers Diploma
13.	SRC	Student Representative Council
14.	STD	Secondary Teachers Diploma
15.	STS	Science Technology and Society

CHAPTER 1

ORIENTATIVE INTRODUCTION

1.1 INTRODUCTION

This study emanates from the development of a pilot multimedia package (MMP) for higher primary science. The project was initiated by the Handspring Trust for Puppetry in Education, a nongovernmental organisation (NGO) whose primary aim is to develop material which assists in the process of upgrading primary school science teaching and learning. This project deals with, inter alia, preconceptions and problem-solving strategies in primary science.

The package was produced in 1992 in collaboration with some individual experts and organizations (e.g. story writing and film companies) with the Handspring Company playing a major role. Science consulting was done by Marissa Rollnick of the Chemistry Department of the University of the Witwatersrand (WITS), (who is involved in science education research) and Michael Kahn, an independent evaluator and education policy unit analyst at the Centre for Education Policy Department (CEPD), in Johannesburg. Implementation and teacher training is organised through Cynthia Dumbrill of the Primary Science Programme (PSP), also an NGO involved in primary school teacher in-service training.

The programme is based on current research findings, (e.g. Bruner, 1975; Magoon, 1977; Driver & Erickson, 1983; Pope &

Gilbert, 1983; William, Murray & Poole, 1992; Osborne, Black, Smith & Meadows, 1993) into how children learn science through the constructivist approach. This approach sees knowledge as "constructed in the mind of the learner" (Bodner 1986:4). This implies that learners will have their own ideas about certain concepts based on their previous experience. According to the constructivist approach the teaching of science should be more than "prescriptive telling" of the "true knowledge" to the learners.

In September 1992 two researchers, Helene Perold and Mary Ann Bahr (Jones, Perold, Bahr & Rollnick, 1992) evaluated the MMP pilot materials for higher primary school science pupils. Their findings established that these materials had an impact on the affective domain (cf.Bloom's taxonomy) of children. Children also identified strongly with the video characters. These characters were also perceived by teachers as good role models, since they "think for themselves".

The evaluators also indicated that the level of English was accessible to pupils despite the pace and clarity of delivery being occasionally unclear. Although there was a concern that the scientific message could be obscured by the entertaining story, it was found that children indicated clearly that the film was about science, specifically about light. Though the materials were not expected to bring about conceptual changes by themselves, the following was observed:

1.1.1 Approximately one third of children modified their misconceptions after seeing the video.

1.1.2 Some children volunteered additional information implying that they had extended their thinking considerably.

1.1.3 After watching the video, twice as many children were able to solve the mirror problem (i.e. to indicate how to use mirrors to reflect light around a corner).

The package is directed mainly at disadvantaged pupils (mostly blacks). The main aims of the package are to stimulate the development of scientific literacy and promote the development of thinking skills and problem-solving strategies, and to address children's fundamental misconceptions in science.

In this study the researcher has started by establishing what specific ideas primary school children (pupils) and pre-service teachers have developed about the nature and behaviour of light, and what prior experiences might have led them to have these views. This was done by administering questionnaires, accompanied by some diagnostic test questions developed by the 'Hand Spring' researchers. The researcher wishes to see whether it is possible to encourage pupils and pre-service teachers to change their prior ideas so as to develop a more 'scientific' understanding of light concepts.

The pilot package is made up of several media:

1. a video drama showing some key concepts in light, such as reflection and rectilinear propagation. This video drama plays for 26 minutes.

2. the same story printed in a comic of 36 pages.

3. a 15 page set of pupil activities which have been designed to encourage the active exploration of the scientific concepts introduced in the story, and

4. the same story broadcast over radio. (This medium was not ready for testing in 1992 and will not be involved in this study)

1.2 THE AIMS OF THIS STUDY ARE:

1.2.1. To identify both preconceptions and misconceptions of primary school pupils and pre-service teachers concerning light.

1.2.2. To remediate misconceptions of pre-service teachers by teaching them relevant and correct scientific concepts about light.

1.2.3. To study the use of the media by pre-service teachers in primary schools, and to investigate the effect the media has on the conceptual change of pre-service teachers.

1.? 4. To train pre-service teachers to use the multi-media package in a reflective manner.

1.3 PARTICIPANTS IN THE STUDY

1.3.1 The involvement of teachers

The researcher wanted to see different teachers, with different approaches to teaching, involved in the study. A uniform style of presentation in all classrooms or schools could not have been possible and was not even desirable. Teachers were encouraged to implement the material in existing classrooms in a way that both they and the pupils would feel as comfortable with the work as they would with any other normal classroom experience. Afterwards teachers were to see to what extent this media had increased or decreased their scientific understanding of the relevant concepts. This would be done by analysing:

1. The attitudes teachers have on the MMP,
2. The approach used by teachers implementing the MMP,
3. How the teachers would behave during the implementation process.

1.3.2 Involvement of pupils and students.

Primary school pupils and Senior Primary Teachers Diploma (SPTD) students were involved in the first session of identifying their ideas concerning the concept of light. A large component of the work was classroom based, and all the participating pupils and pre-service teachers were involved as far as possible. To facilitate more detailed discussion of their thinking during the

activities, several questions were asked (by the researcher) and the responses noted down (except where there was repetition).

1.3.3 Involvement of in-service teachers.

It was not primarily the aim of the researcher to involve in-service teachers in the project since this had already been done before (Bahr & Perold, 1992; Bahr & Perold, 1993). But since they were readily available and very interested in the material the researcher requested them to assist in the distribution of pamphlets and in writing pupils' responses to questions asked by the researcher. Some of the responses resulted from informal interviews of the pupils by both the researcher and the teachers. As the word "ray" does not exist in the vernacular, pupils were requested to explain how light moves from one point to another using arrows. All responses were written behind each pupils' work-sheet for easy analysis by the researcher.

1.4 PHASES OF THE RESEARCH PROJECT

The research process was divided into three phases, viz: Pre-test, Intervention and Post-test.

1.4.1 Pre-test

This was mainly based on the establishment of ideas of both pre-service teachers and pupils and familiarization of pre-service teachers with the material they were going to use. This occurred

in the first stage and was seen to be important since a different method of teaching was expected by pre-service teachers as compared to the commonly known "transmission method". The researcher intended not to dictate to pre-service teachers a specific method of teaching, while on the other hand wished to encourage them to do away with the prescriptive telling of facts as a teaching method. This approach intended to make pre-service teachers incorporate constructivist teaching techniques into their individual style of teaching, instead of the usual traditional teaching techniques imposed on them (teachers).

During the pre-test stage the researcher collected pupils' and teachers' ideas [illegible] posters of different drawings, and in some cases using que[illegible] These techniques were as follows:

1.4.1.1 Using posters

Pupils and teachers were provided with posters showing, for example, video animation, a mirror and board, a torch, and a boy or girl looking at a tree, and were then asked to draw how light helps the girl to see the tree, or herself, in the mirror etc. (see Appendix C). Thereafter each pupil or teacher was requested to explain in his/her own words what the picture meant, i.e. where does the light come from, and where it has gone to, in order that the boy or girl can see the tree, or him/herself in the mirror.

1.4.1.2 Structured writing and drawing.

As explained in 1.4.1.1. above, copies of posters were supplied

to both pre-service teachers and pupils, during the time of data collection. The respondents were then asked to draw arrows indicating how light could aid vision. The respondents were asked to give further explanations of their diagrams. Each explanation was written behind each copy of the poster provided. Pupils' explanations were either written by the researcher or their in-service teachers in order to save time and avoid illegible writing. The written work produced was informative since it displayed more of the respondents' ideas, and some inferences and conclusions were made from it.

The completion of drawings on the posters gave the researcher and the assisting teachers s(opportunity to talk to individual pupils and build up a picture of their individual understanding. An open-ended questioning style was used. Respecting what the pupils said, and listening to their responses carefully, played an important role in clarifying the meaning of what they wanted to say.

Any idea was taken as it came, without clear opposition, rejection or acceptance. This, in a way, made pupils gain confidence in responding to questions and participating freely without fearing to give "wrong answers".

1.4.2 Intervention

During the intervention the pre-service teachers were encouraged to make the ideas presented to pupils real, concrete and

tangible. Where possible, real material was to be used. They were also made aware that these ideas and experiences needed to be presented in a way that would allow pupils to feel a connection to them. Presenting information, ideas or activities in isolation should be avoided. These were done as attempts to :

(a) Encourage children to test their ideas (conceptual change, Hewson & Hewson; 1987). Here it is assumed that if pupils are provided with an opportunity to test their ideas, then there is a possibility of them finding some of their ideas dissatisfying. This will encourage them to develop their thinking in a much more scientifically accepted/inclined fashion.

(b) Encourage children to increase their scientific vocabulary through different activities ('science is fun')!

(c) Testing the "scientifically correct" idea alongside their previously held notion(s) (Driver, 1970; Hewson 1982; Driver et al. 1985).

Teachers were encouraged to give pupils some activities which involved problem solving. To complete the activity, a scientific idea had to be applied correctly, thus challenging the pupils' notion(s). This confrontation was aimed at helping the child to develop more scientifically acceptable concepts.

1.5 IMPLICATIONS OF THE RESEARCH

The study is aimed at improving both primary school science teachers' and pupils' interactions and their active involvement

in their classroom activities. It is the researcher's conviction that, as both teachers and pupils are actively participating in lessons, their attitudes and approach towards scientific concepts will change, and be developed towards an improved way of tackling scientific problems. The culture of indepth criticism and analysis of natural situations will be cultivated, and hence a better teaching and learning of science will be envisaged ultimately.

1.6 STRUCTURE OF RESEARCH REPORT

1. Chapter 1 discussed introduction to research report, aims of the study, participants in the study and phases of research project.
2. Chapter 2 reviews the literature on the importance of primary school science teachers, the incorporation of story-telling in science teaching and promotion of fun in science lessons.
3. Chapter 3 explains the research methodology.
4. Chapter 4 gives results and discussions of diagnostic tests conducted with primary school pupils, pre-service teachers and in-service teachers.
5. Chapter 5 discusses a survey conducted with the D.E.T. college lecturers at RADMASTE centre in January 1994.
6. Gives a summary of the research findings, implications and recommendations.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

2.1 IMPORTANCE OF PRIMARY SCHOOL TEACHERS

Primary school teachers are responsible for laying a good foundation for the whole education process as the learner progresses towards adulthood. As such it is expected that these teachers should be very well qualified to carry out this task properly. According to the literature, primary school science teachers are doing a capable job elsewhere (Stefanich & Kelsey, 1989), in spite of an 'inadequate' science background. Unfortunately, this is the opposite in most South African schools, particularly African schools. Jones et al. (1992) report that a high number of African teachers are underqualified and rote learning is still a major problem.

Mphahlele and Kahn (1993:157) indicate that according to the National Party's educational policy "the means of science knowledge were to be solely in the hands of Apartheid Ideologues. The majority of people (Blacks) were and are still excluded from the pursuit of science. Access to both resources and knowledge are limited to the minority".

According to Kahn (1993:7) the Bantu Education Act of 1953 resulted in a "failure to maintain quality African education

institutions where some education opportunity for the future elite corps could be provided. One of the set of these decisions is the present poor state of science and mathematics education and lack of skilled African personnel". He (16-17) further indicates that "..... very few PTD students take physical science as the major subject whilst at college. This is well illustrated by the situation at schools managed by DEC:R (Department of Education and Culture: House of Representatives (Coloureds)). In the system most so-called primary science teachers have had almost no teacher education in physical science since it is not offered as a college subject beyond first year. Consequently they struggle with the subject, contributing very little to the eventual production of a few matriculants in physical science."

The issue of poor qualification of science teachers is also pointed out by Joubert, Joyce and Cloete (1992:5) when talking about South Africa beyond 2000. They say "The creation of a healthy, well developed feed-stock into our schools, universities and technikons is almost sine-qua-non. There is an eternal outcry about South Africa's seventeen departments of education, unqualified teachers, poor teacher salaries, inappropriate syllabi, ..."

To solve some of these problems a new powerful science educational programme which includes several strategies that will address both teachers' and pupils' needs, has to be developed (Akindehin, 1988; Jones et al., 1992). Such programmes could effect changes or improvement to teachers' attitudes and

conceptions they have about science (in this case light). The literature reports that teachers with negative attitudes towards science are more traditional in their teaching style, more closed-minded and generally more resistant to curriculum change (Stefanich & Kelsey, 1989; Akindehin, 1988). Lucas and Dooley (1982) found that the methodology (didactics) course affected student teachers' attitudes towards science teaching. This means that student teachers should be exposed to methods which can affect their attitudes towards science in a positive way. Hewson and Hewson (1987) indicate that for one to change the students' original concepts, the new concept advertised needs to be intelligible, plausible and fruitful to students; otherwise students will not see any value in changing their original concepts for the new ones.

2.2 INCORPORATING STORY-TELLING IN SCIENCE TEACHING

A way of changing students' or pupils' conceptions is by introducing story telling in the process of teaching. Story telling is also acknowledged to have the power to direct and change pupils' lives (Carter, 1993). She indicates that the study of narrative has now become a positive source of insight for all branches of the human and natural sciences. Carter's view of story telling in teaching is supported by Bulman (1980) in her studies of problems encountered by second language English speaking pupils when they had difficulties in expressing their scientific ideas in English. Bulman expresses the feeling that much writing in science does not encourage pupils to start or

continue reading. She views science content as being written in an impersonal style with few human, social or emotional tones, thus making science appear 'extraordinarily' dull.

The centrality of story in teachers' knowledge is understood by the effort to see the story as a natural and common mode of thinking. Elbaz (1991: 3) argues: 'story is the very stuff of teaching, the landscape within which we live as teachers and researchers, and within which the work of teachers can be seen as making sense. This is not merely a claim about aesthetic or emotional sense of fit of the notion of story with our intuitive understanding of teaching, but an epistemological claim that teachers' knowledge in its own terms is ordered by story and can be understood in this way'.

2.3 PROMOTION OF FUN IN SCIENCE LESSONS

Carter's (1993) and Elbaz's (1991) views are shared by Williams et al. (1992); they brought drama into the science curriculum, aiming to produce a resource by which drama could be used as an aid for explaining difficult concepts either alongside traditional methods (e.g. experiment and exposition), or as a substitute for them. Implicit in this was the wish to develop a resource which would promote a sense of fun, as well as encouraging young people to learn science. They argue that creativity and drama have an important role in the motivation, stimulation and effective learning of science by pupils, regardless of ability, in learning. They emphasise that drama, as one of the creativities in the classroom, is just a small

portion covered, and that much can still be done to improve the classroom situation towards a more scientifically conducive learning situation. They see drama in the science curriculum as a subject which is currently drawing considerable attention. Some teachers and educationalists see it as progressive, while others see it as irrelevant to the learning of science. However many pupils enjoy drama, and for some lessons it represents an opportunity for them to express themselves without having to use pen and paper.

In brief, the literature discussed above is in line with the MMP, which aims at improving general science teachers and encourage them to be more accommodating towards curriculum change. Furthermore, it incorporates story-telling in science teaching and has a potential of promotion of fun in science education by including drama in science curriculum. The successes and limitations of the MMP are described in the two forthcoming chapters.

CHAPTER 3

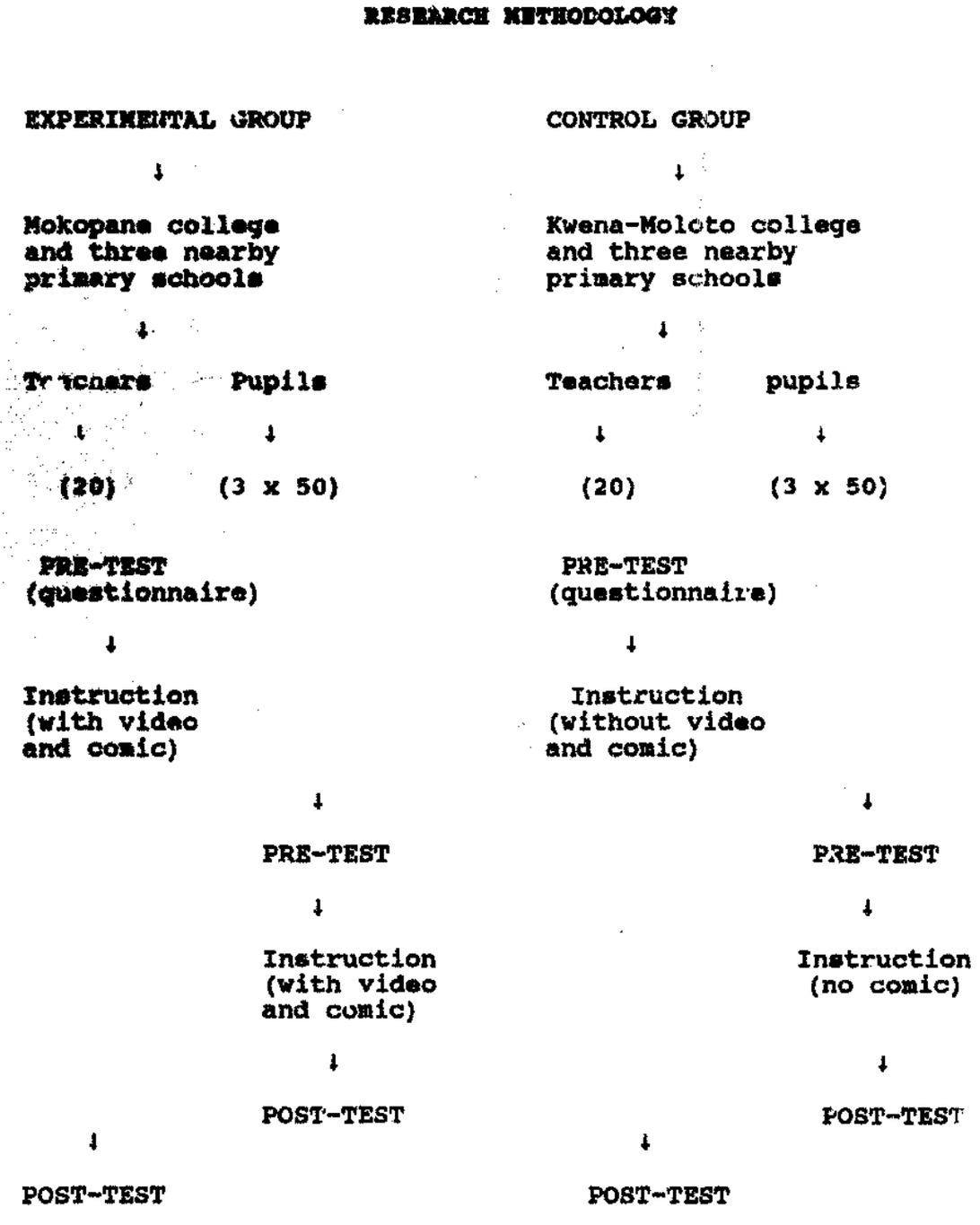
METHODOLOGY

3.1 [illegible]

[illegible] and six primary schools were chosen to be involved [illegible]. The SPTD (Senior Primary Teachers' Diploma) [illegible] from each of the two colleges together with three [illegible]ools around each college were requested to participate [illegible] flow-chart in Figure 3.1). The colleges are Mokopane and [illegible]oto near Potgietersrus and Pietersburg respectively.

The research design involves experimental-control groups which consist of pre-test, intervention phase and post-test. Mokopane college and the three nearby primary schools were considered as the experimental group; whereas Kwena-Moloto and the corresponding nearby primary schools were the control group.

Figure 3.1 Flow-chart of research methodology



3.1.1 Teachers

3.1.1.1. Both groups of pre-service teachers were given the same pre-test in the form of a questionnaire containing some diagnostic test questions about light, as well as a further diagnostic test (see later under instruments).

3.1.1.2. During the intervention phase both groups received instruction on the topic, light. The control group was taught without the use of the MMP, whereas the experimental group was taught using the MMP.

3.1.1.3. Both groups were supposed to receive the same post-test, which is a repetition of the same instruments used for the pre-test.

3.1.2 Pupils

3.1.2.1. The diagnostic test questions only were administered (by the researcher) to pupils, so that pupils did not face the problem of understanding the questionnaire.

3.1.2.2. The intervention stage was supposed to have been carried out by the pre-service teachers during their practice teaching. The control group was to teach without the aid of MMP while the experimental group was to teach using MMP.

3.1.2.3. The post-test would then be the same and was to be administered in both cases by the pre-service teachers.

3.2 DATA ANALYSIS

A descriptive analysis was to be carried out i.e. the means and standard deviations obtained from the results would be used to compare the groups and general inferences would be made from these comparisons. The data analysis was to be handled in this way because :

-- The pre-service teachers and pupils who were to be involved in this study were from different schools/institutions and they had different abilities.
-- There would not be a suitable method to control the pre-service teachers' school allocation.
-- The sample of this study was small.

3.3 DESIGNING A SHORT QUESTIONNAIRE

Children's ideas in science, and associated preconcepts, which normally affect their understanding of the scientific meaning of words or concepts must be taken into consideration. It is believed that, even in the case of "light", there will be intuitive ideas affecting the understanding of the concepts. Hence, the questionnaire is designed for identifying any intuitive ideas or preconceptions teachers and pupils have about light (Driver, Guesney & Tiberghien; 1985). Research has also indicated that both pre-service and in-service teachers have misconceptions about science concepts (Bradley, Gerrans & Mathee, 1989; Ogude, 1991; Stefanich & Kelsey, 1989).

3.3.1 Instruments

3.3.1.1 Questionnaire

The questions used in the questionnaire have been adapted from the work of Galili, Bendal and Goldberg (1993). The format of the questionnaire is multiple-choice and includes confidence questions. This is because by using a multiple-choice test alone, there is no guarantee that students answering correctly have the same conception in mind as the experimenter (Clement, Brown & Zietsman; 1989). Therefore multiple-choice questions are supplemented by some further enquiries, like the confidence questions, which are included immediately after each question, and the diagnostic test questions (see Appendix C).

3.3.1.2 The diagnostic test

The diagnostic test is taken from the Handspring Trust for Puppetry in Education (PSP, 1992) research materials. This test was first used in the development of a pilot MMP for higher primary science and was administered to both pre-service teachers and pupils to detect whether pre-service teachers have the same alternative conceptions held by pupils or not. The diagnostic test differs from the questionnaire (described above) in the following ways:

a. The questions in the diagnostic test are not multiple-choice; instead they are open-ended.
b. The respondents are expected to participate in the activities and reflect their own views/ideas by drawing the light rays.

c. The test design enables the researcher to interview the respondents while he is in the process of administering the test (see Appendix C).

The diagnostic test was seen as the most effective way that could be used to identify the ideas of the respondents (pupils in particular), because it has assisted in eliminating problems that could be encountered by the pupils in understanding the instructions and written language, if they were requested to complete the questionnaire.

This chapter attempts to lay out a structured investigation of both the pre-service science teachers' and pupils' understanding of light and to explore the effects of intervention strategies in the process of implementation of MMP. The results and data obtained from the implementation of the investigation(study) will be discussed in the next chapter.

Chapter 4

PRE-TEST

4.1 EXPERIMENTAL GROUP

4.1.1 Description of Mahwelereng Area

As has already been indicated in chapter, six primary schools and two colleges of education were visited. The research project was conducted in two different areas. One of the areas is Mahwelereng, 4km from Potgietersrus. Mahwelereng is a small African township. Many people from Mahwelereng are Ndebele speaking, but they commonly speak Northern Sotho, as it is the language which is generally used in most public areas in Lebowa, including schools, churches, government offices, etc. Therefore every Ndebele of this area knows N.Sotho very well and it is their second language. As such, English and Afrikaans are third and fourth languages to them.

The researcher chose three schools in the area, i.e. Maakamaleka, Raphela and Nonchimudi Higher Primary schools. These schools were chosen because they either had electricity in their vicinity, or had access to electricity in one way or another. Thus it was possible for the researcher to show pupils a video. According to their teachers, some of the children from Raphela and Nonchimudi are from the nearby villages, such as Moshate (meaning chief's Kraal) and Ga-Madiba. These villages are also a bit advanced relative to the standards of living of the nearby Mahwelereng township, where only about 45% of families have television. Some

families with television do not have electricity, but depend on their car batteries or generators. These families only view television during specific programmes, especially the evening news, and the drama broadcast in the vernacular. Those who have television sets, normally watch them with their neighbours who don't possess this equipment. The children who stay next to shopping areas sometimes watch television at nearby stores. In general, pupils have some access to television, though this might depend on several variables. Their access to television cannot be compared with that of the children in the PWV areas.

The three schools in Mahwelereng are basically similar since they are all in the same locality and serve the same community and, above all, are subjected to similar physical conditions.

4.1.2 Diagnostic test at Mahwelereng Schools

The researcher was given a chance to administer the diagnostic test questions to Std 5 General Science pupils at Raphela primary school, though the targeted class was Std 4. The researcher only realised during the testing process with the pupils' identification information on their test papers that they were doing Std 5, but decided to continue with the testing process.

During the testing process at the three schools, the pupils were supplied with pictures of different drawings and then requested to explain what they saw on the picture. Several probing questions about light were asked. Many pupils could not respond

in English and they also had some difficulty in understanding what was really asked. The researcher saw the usage of vernacular sometimes mixed with English as an alternative.

The pupils felt more comfortable and participated more when questions were asked in the vernacular. This has generally been the case in all three schools. When their teachers were asked what medium of instruction they were using, they responded by saying that English was the medium. However, pupils are still having serious problems with it. [It should be noted that the teaching of these children at lower standards starts with the vernacular and the use of English as the medium of instruction is only introduced at Std 3 level].

4.1.3 College at Mahwelereng

This college, Mokopane, is one of the oldest colleges in Lebowa. The college has four laboratories i.e. chemistry, physics, botany and zoology laboratories. The laboratory equipment is supplied by the Lebowa Education Department. Those responsible for the ordering of this equipment do not work in co-operation with the lecturing staff and, as such, the limited equipment available is of little use for the college syllabus. The college syllabus has just been upgraded so that first and second year students learn more about Science Technology and Society (STS), which has been introduced to the colleges through recommendations which resulted from research work done at Wits. Some first year university work is introduced to the second year and third year college syllabus.

There is little or no equipment which caters for these syllabi.

The college students are from different high schools. Most of them did not achieve the requirements for university or technikon entrance. Still, the admission for science students requires them to have passed the national senior certificate (STD 10) in both mathematics and physical science. This criterion, coupled with the class boycotts and disruptions, caused the number of the physical science students admitted to be very low. Out of the whole college student roll of 1500 only 90 are doing physical science, i.e. an average of 15 students per physical science class where STD and PTD have courses 1 up to 3 and at least four classes per course; each course offering one physical science class.

4.1.4 Testing of Mokopane teachers

This research was carried out in 1992, under the stressful conditions of South Africa undergoing transitional changes. Struggles were experienced all over. Mokopane college had class disruptions since the death of Chris Hani (One of executive members of the ANC-SACP alliance) around the Easter holidays in April until they closed for the June holidays. No single test was written since the beginning of the year until they re-opened on 27 July. They only started writing their first test after re-opening for the second quarter. A week later, before tests were completed, members of South African Democratic Teachers Union (SADTU) went on strike. Hence the remaining tests were not

written. This was the exact time arranged for the completion of the questionnaire and administering the diagnostic tests. Since other pre-service teachers realised that their tests were not ready, they simply disappeared and the researcher managed to organise only eight students out of thirteen.

The testing process occurred in the physics laboratory. It started with explanations of the whole process by the researcher and continued with pre-service teachers answering the questionnaire. Then, the same procedure used to test pupils, was followed with teachers. Teachers were probed with several questions, but the activities like "hiding someone behind the door", were not carried out since the researcher felt that they would not be suitable for teachers at their age. In other words, the researcher tried to avoid activities which, by his own discretion, he felt would only be suitable for young pupils.

The pre-service teachers responded quietly. According to the Department of Natural Sciences this group of teachers has the poorest performance as compared to the previous groups. This was also confirmed by their class teacher, who is a guidance lecturer. Later, after the diagnostic test, the researcher briefed teachers on matters where they would be assisting him in the implementation of the project about the stages which would follow thereafter. The researcher realised that though the group seemed to be too quiet, there was some sense of co-operation. When asked as to who would volunteer in the implementation of MMP at primary schools under the supervision

and evaluation of the researcher, all teachers raised their hands indicating that they were interested. When asked whether they had any questions to ask or any comments to make, they all quietly shook their heads, indicating they had none. After some persistence by the researcher one student said that perhaps more questions might be asked during the intervention stage. The whole process took three and half hours.

4.2 CONTROL GROUP

As mentioned above the control group consisted of one college of education (Kwena-Moloto) and three nearby primary schools (i.e. Tsutsumetsa, Samuel Thema and C.M. Sehlapelo). These institutions are located in Seshego (an African/Black township), which is located about 10km from Pietersburg. The language spoken by almost everybody in this township is Northern Sotho.

4.2.1 College at Seshego

Kwena-Moloto is a relatively old college of education established in the middle 1970s. It has some biology and physical science laboratories. The shortage of physical science students is also experienced at this college. Only six science students had enrolled for the PTD 2 by 1993. This might be attributed to several factors:

i Lack of better-qualified science teachers at secondary schools to produce more students with good results in science for tertiary education enrolment.

ii The teachers' strikes experienced throughout the country.

iii Strict measures taken when admitting physical science students at colleges.

4.2.2 Description of Seshego Area

When comparing Mahwelereng and Seshego, the latter looks better developed with a few more educational advantages. Seshego is near Pietersburg, which has a more highly developed infra-structure and facilities than Potgietersrus. Both Pietersburg and Seshego are about 35km from the University of The North. Some people in the area attend this university and some are even employed there. Many people in Seshego own television sets. From the first encounter with some children (at Tsutsumetsa) the researcher was impressed to find pupils not hesitant to answer questions in English. Most of the pupils' English was found to be good, particularly at this school.

It is not clear whether these children's parents give them extra language lessons or if it is simply due to their exposure to the language through the electronic media, such as the radio and television. Some pupils attend the computer aided learning sessions at Kwena-Moloto college.

In general, the schools at Seshego are ordinary township government schools with large classes. Teachers are not always able to move freely between desks while teaching. Even though

there are a few variables which could contribute to the difference of pupils and students, one can still view the Seshego and Mahwelereng groups as fairly similar.

4.2.3 Diagnostic test at Seshego schools

The three primary schools were visited one after the other and diagnostic tests were administered in the same way as it was done in the experimental groups in Mahwelereng Schools. Where the pupils struggled with English, the researcher always encouraged them to speak in the vernacular. They were also made aware that it was their thoughts which were particularly of interest to the researcher, to compare them with those of the experimental group.

4.2.4 Testing of Kwena-Moloto teachers

Unfortunately, it never became possible for the researcher to get hold of the pre-service teachers from Kwena-Moloto, due to the national strike by teachers. Some plans were made to meet these student teachers while they were at their practice teaching schools, but unfortunately this did not materialise. The pre-service teachers were consulted individually and were requested to assemble at the college for a briefing by the researcher. This would also serve as a chance to administer the diagnostic tests and questionnaire to them; but only one teacher turned up with several excuses that she had to go to town, while some were at a SRC meeting and she didn't know where the rest were.

Further attempts to secure a chance to meet these pre-service

teachers proved impossible. The researcher then handed some questionnaires to their science lecturer to administer whenever classes resumed, but, unfortunately, this never occurred.

4.3 FINDINGS FROM THE TEST

The diagnostic test was mainly based on four questions. These were:

a. The boy watching the tree
b. Video animation taken from a section of the comic
c. The girl watching herself in the mirror and again trying to watch herself in the board
d. The boy holding a torch

Examining the data received after this test, several areas of interest were identified in each question asked.

4.3.1 The boy watching the tree

Both children and teachers were asked to draw how the light from the sun helps the boy to see the tree. The drawings are grouped as follows:

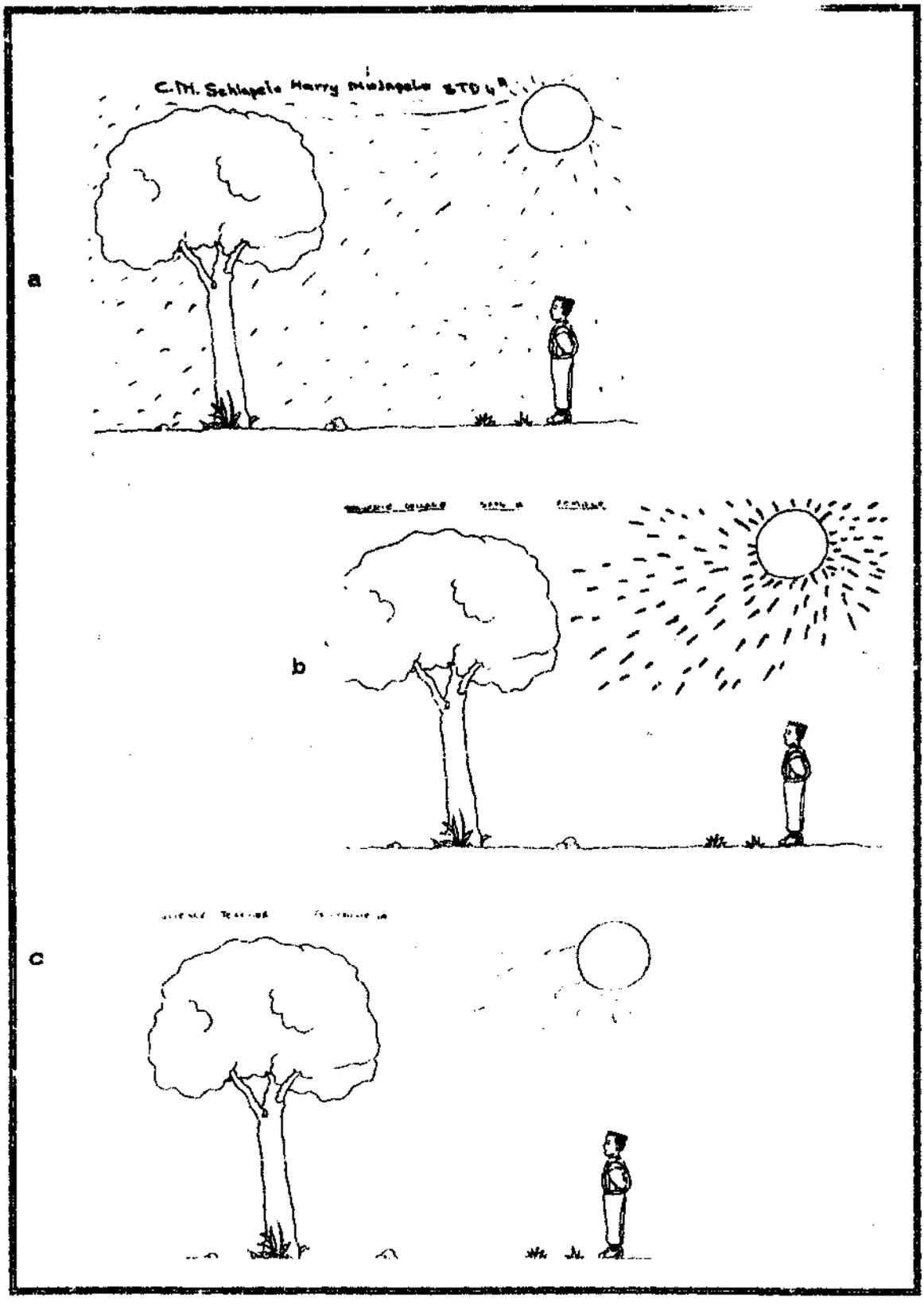
a. Those that represent a flash or shower of light from the source in all directions.
b. Those that represent light in undirected rays.
c. Directed light rays from the source.

A few examples will be discussed to indicate what the pupils' and teachers' ideas concerning light are.

4.3.2 Vision viewed as a flash or shower of light

Figure 4.1 a, b, and c show the responses of both pre-service teachers, in-service teachers and primary school pupils. They all believe that "the sun shines over every thing so that the boy can see the tree".

Fig 4.1 A flash or shower of light



This indicates that these respondents believe that there should be light all over in order to aid vision. After further questioning, this idea changed when they were asked what would happen during the night if a passing car was shining light on the tree while an observer was behind the car. This question made many of them reconsider their former belief and indicate that the observer would see the tree. Which means that light need not necessarily shine all over in order to aid vision.

4.3.3 Directed rays from the source to tree.

A variation of rays were drawn to indicate that light travels from the sun and shines on the tree so that the boy could see it. See Figure 4.2 a-c. Many children and their teachers (both in-service and pre-service) provided drawings that showed simple links between the object and the source without any link between the object and the eye. To them vision can only occur if light is "shining" on the object which they see.

4.3.4 Link between object, source and eye

Some respondents drew rays which link the sun with the tree and the other link is between the eye and the object to be seen, as indicated by Figure 4.3. This was done in two ways. One way is whereby an arrow is directed to the source implying that vision is an active process. This implies that for one to look at an object there is a required action of throwing one's eyes on a targeted object; that light should be reflected into the obsever's eye is not understood.

Figure 4.2 Directed rays from source to the tree

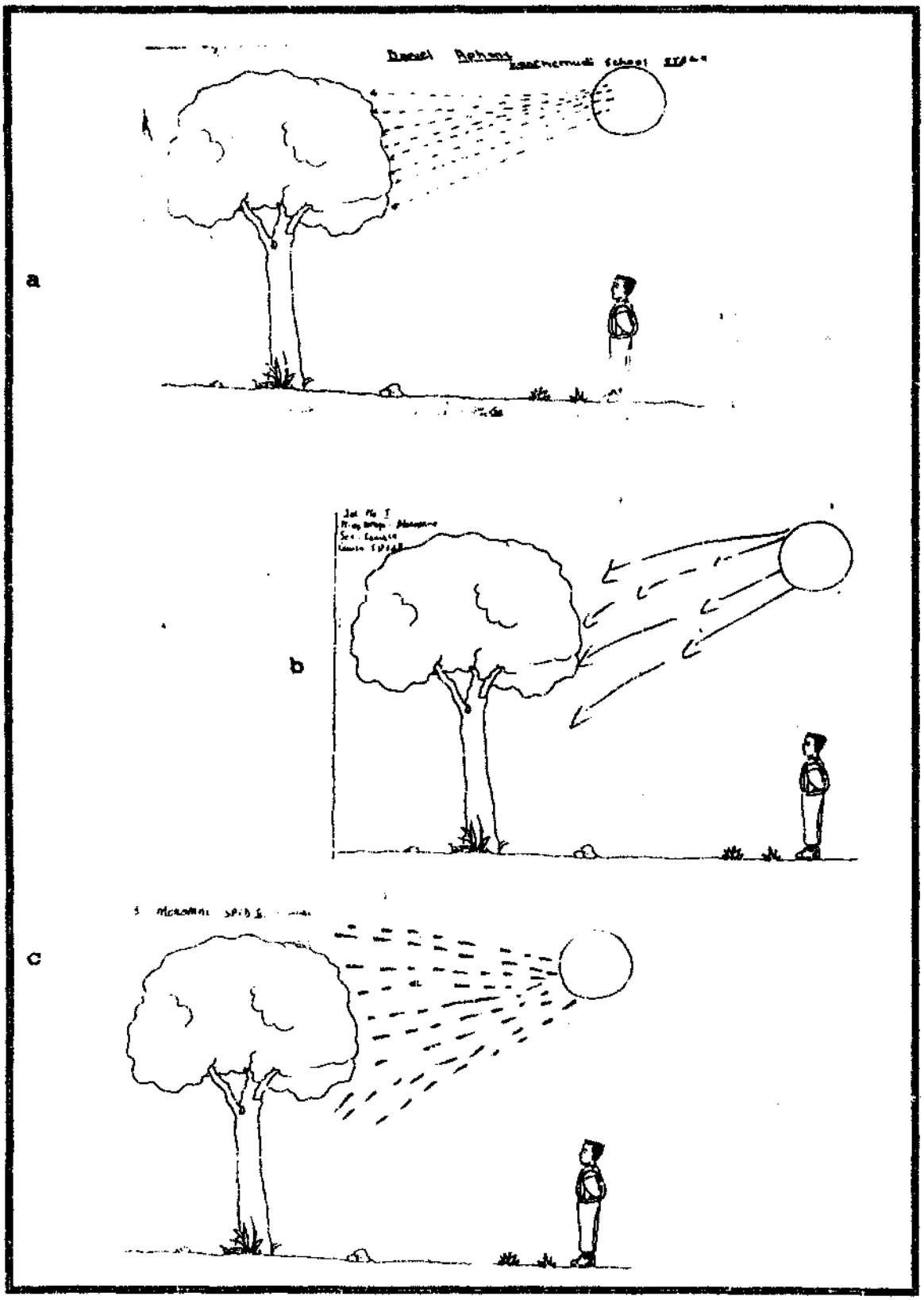


Figure 4.3 Links between the source, object and the eye

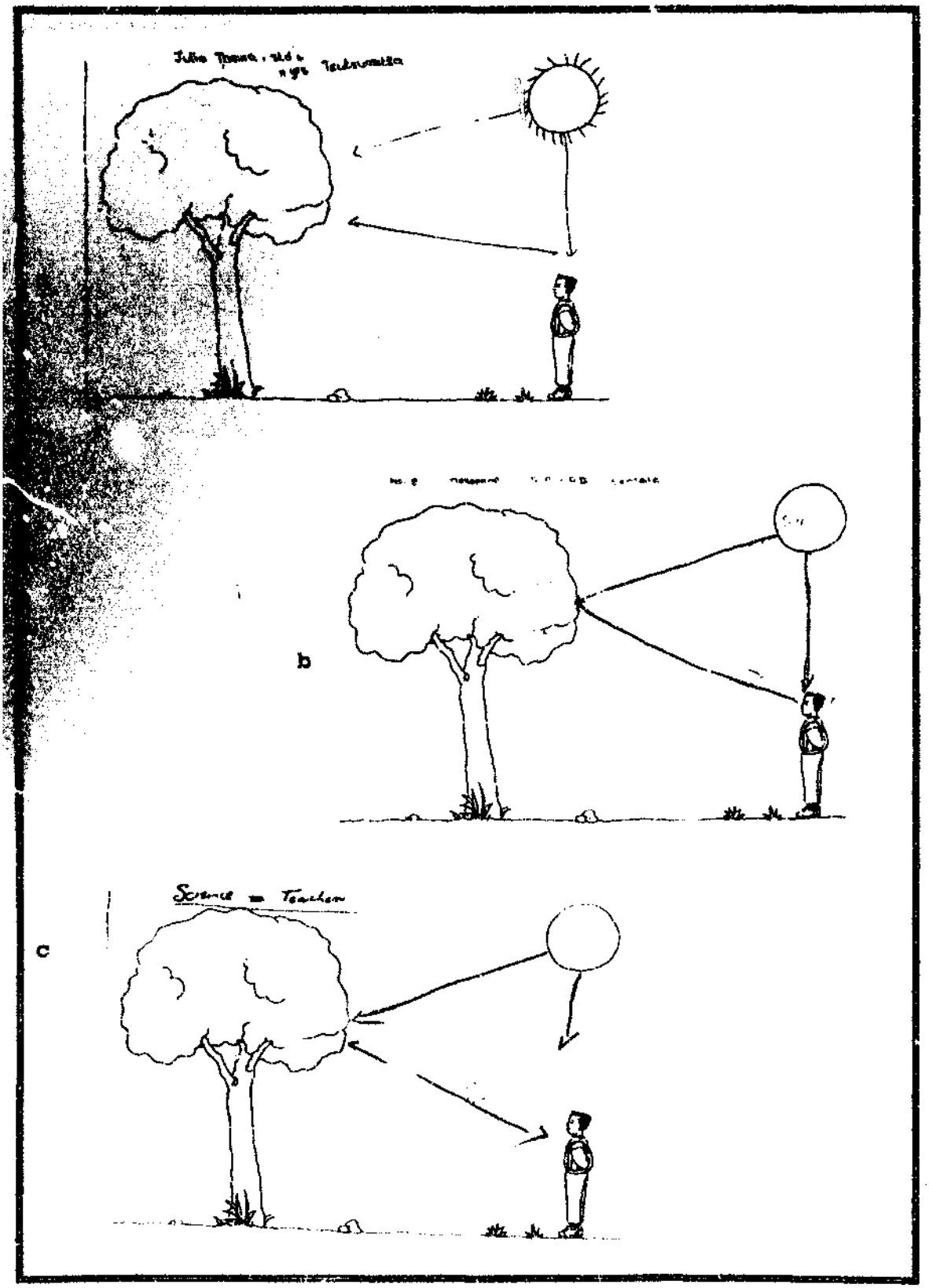
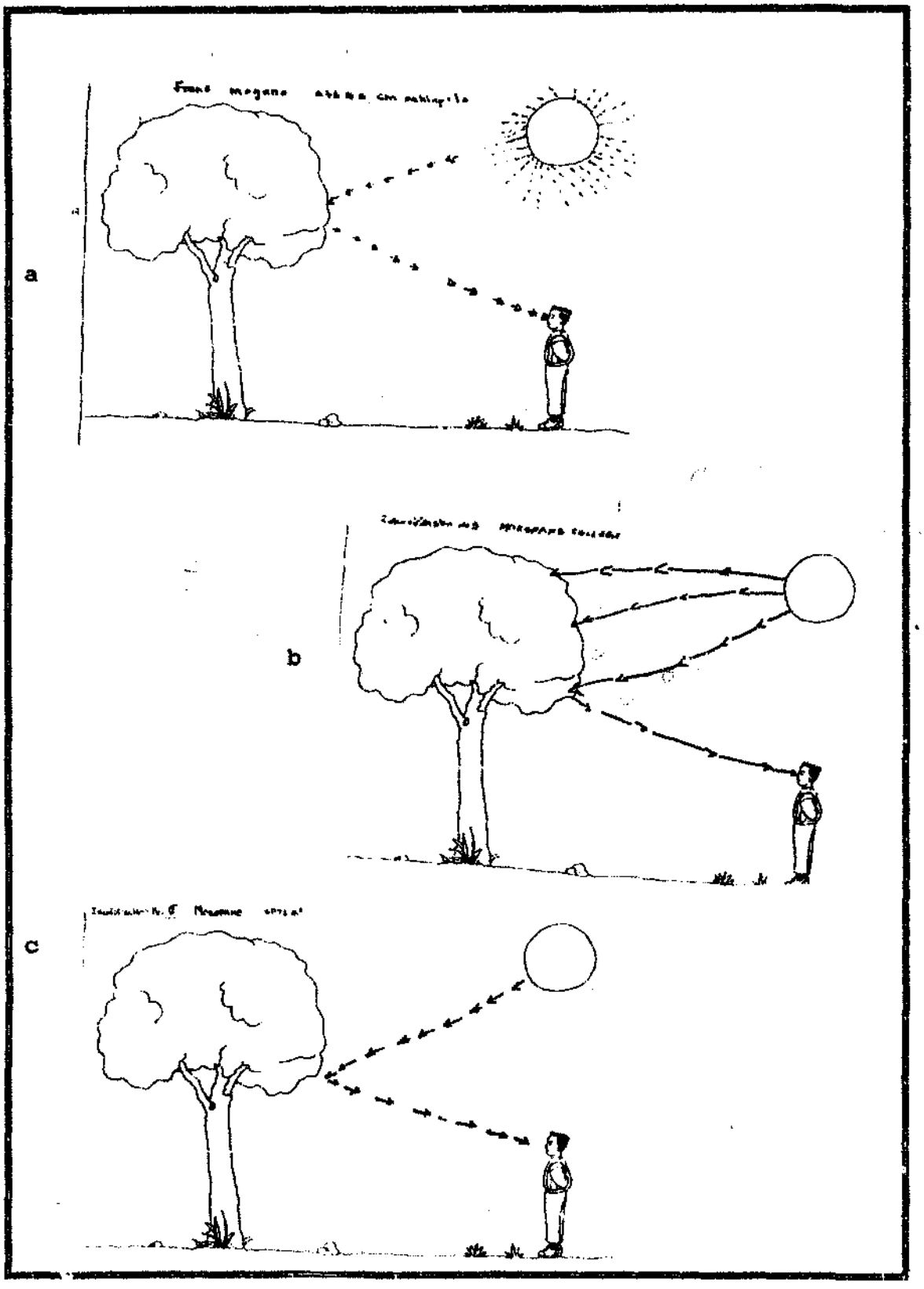


Figure 4.4 Correct conception of vision



Another active process was whereby light is travelling from the sun shining on the boy, while the boy is actively looking at the tree. However, some respondents had the correct conception of reflection of light from the target object. This is indicated by Figure 4.4 a, b, and c below.

However, very few pupils achieved this and again they were not very clear on what happens to light to enable the boy to see. The number of all incorrect and correct responses could be clearly seen from Tables 4.1 to 4.4 in Appendix F.

4.4 VIDEO ANIMATION

Here many respondents did not have serious problems because the researcher decided to introduce the activity with the mirrors before any drawings could be made. The researcher then gave them a poster indicating a trapped boy in a dark room with the light coming from the sun-roof of the adjacent room (see Figure 4.5 below), and asked the respondents to draw how the two children would shine light over the trapped boy in order to help him. Different responses were given (see Figure 4.6 a - f). It is indeed quite obvious that many different types of Figures were drawn. This might be attributed to the complexity of the situation itself, but many children and teachers managed to get the correct answers (see Table 4.2).

Figure 4.5 Example of video animation poster

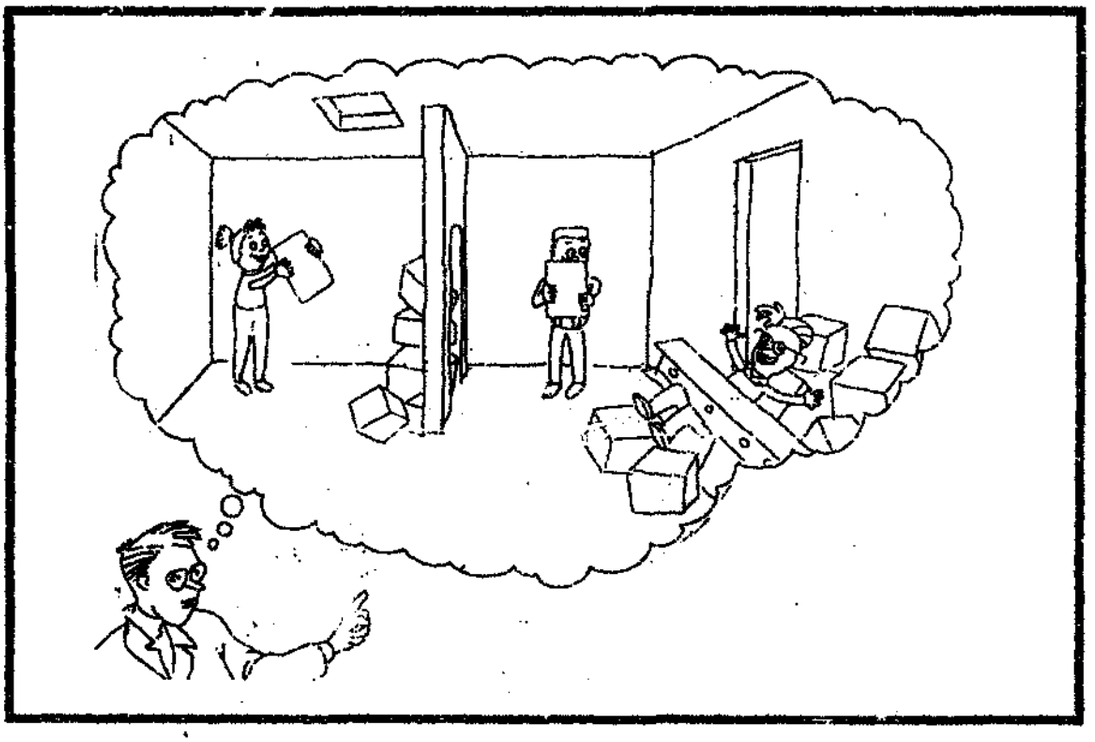


Figure 4.6a Responses to question of video animation

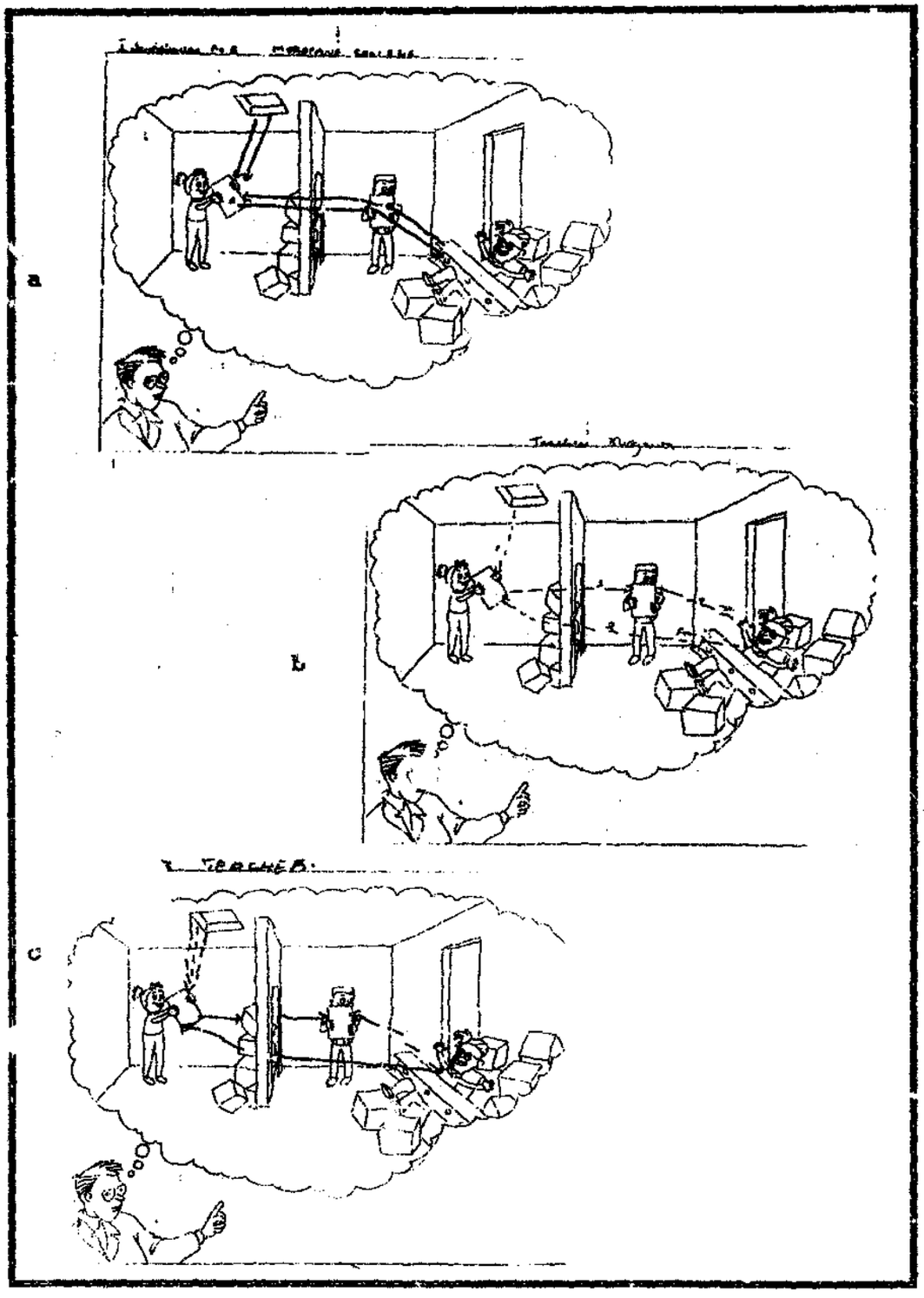
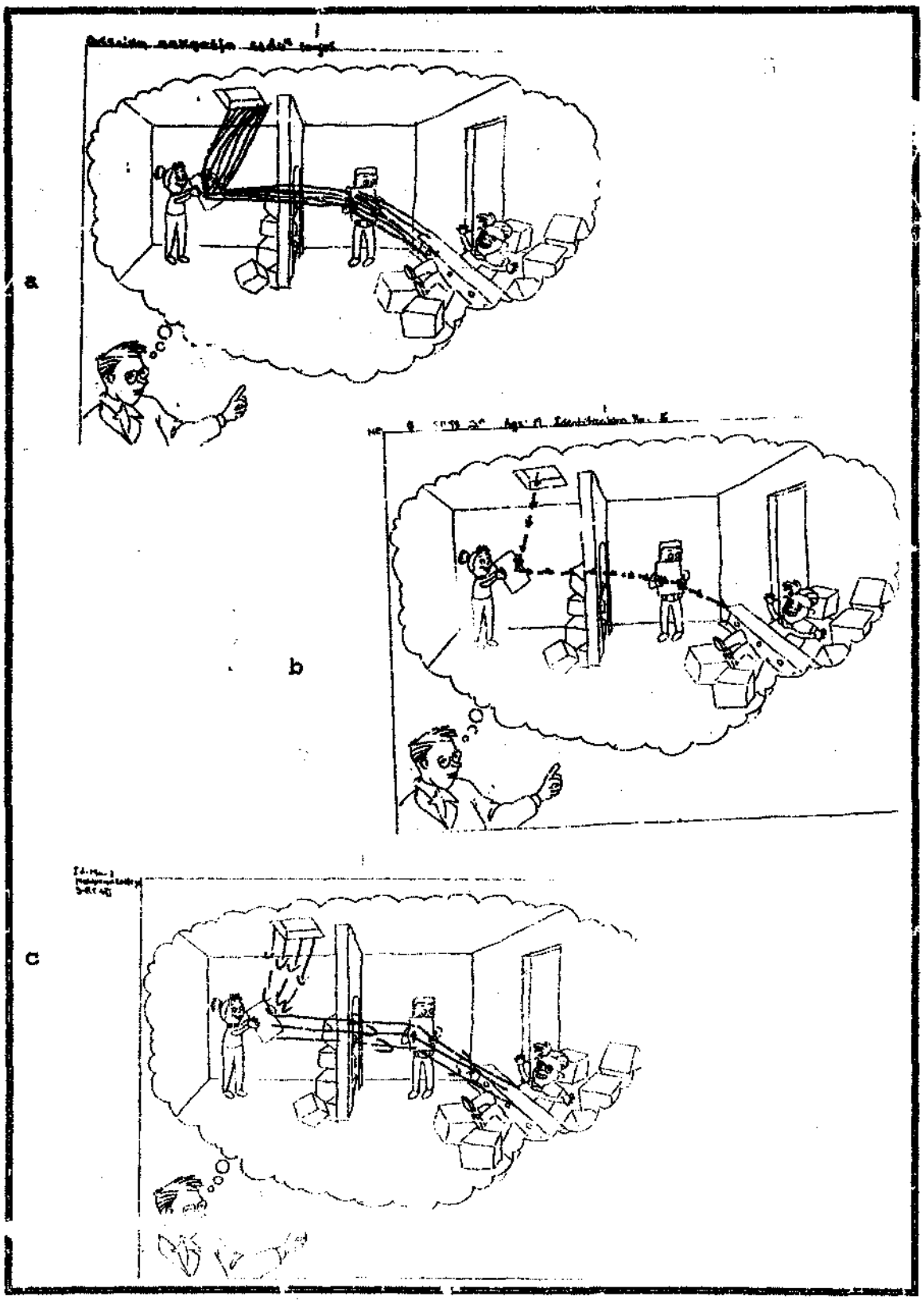


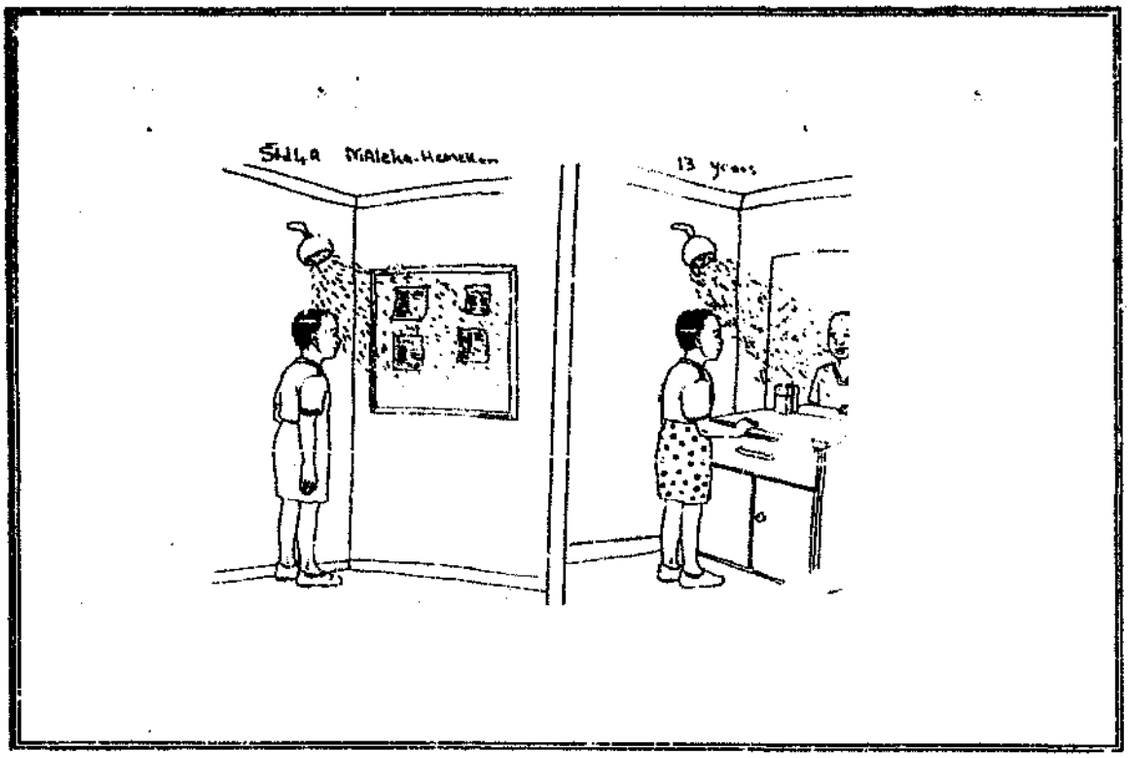
Figure 4.6b. Correct responses to question of video animation



4.5 MIRROR AND BOARD

Again this was classified into the different ray types given by respondents. Almost all ray types given by pupils were given by teachers. A summary thereof is given in Table 4.3. The dominating ray types are the beliefs indicated in Figures 4.2 and 4.3 above, of seeing vision as a result of either a shower of light all over the place (Figure 4.7a), or as a single directed arrow or a beam of arrows from the source to the object.

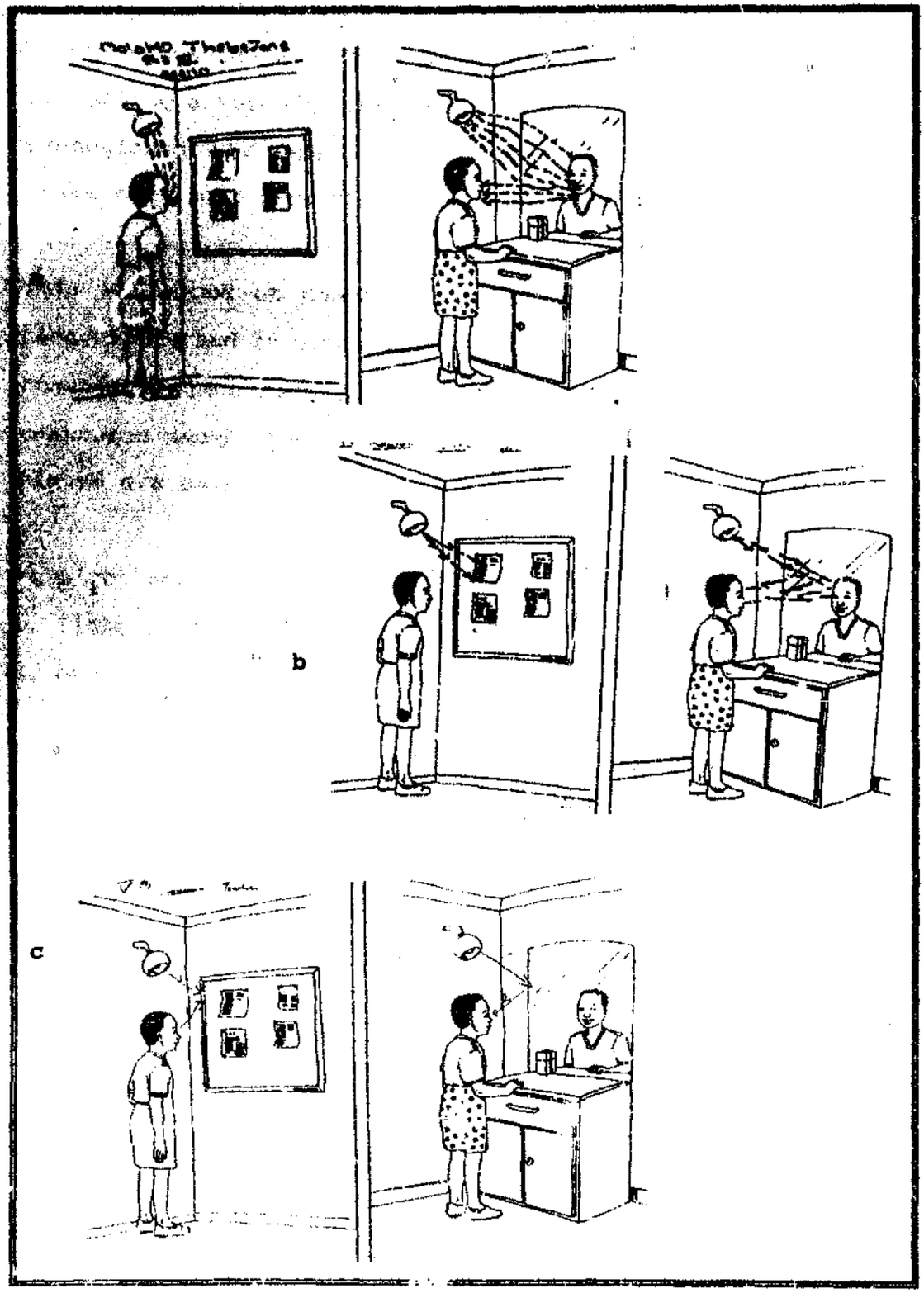
Figure 4.7a A shower of light on a mirror and board question



Here the question mentioned that " ....the girl can see herself in the mirror. The girl cannot see herself in the board. Try to show what is happening to light on your drawing".

A very small percentage of pupils managed to indicate the correct conception of light from the source reflected into the girl's eyes; 6.% of pre-service teachers indicated the correct conception. This occurs mainly on the mirror drawings and not on the board. It is interesting to realise that many respondents still believe that if material is not shining, light travels from the source and 'stays there' i.e. on the material concerned. It is not reflected back. Light can only be reflected when the material surface is shiny, and light is very intense resulting in a high reflection. This is revealed by drawings in Figure 4.7b below.

Figure 4.7b Light reflection by mirror or board



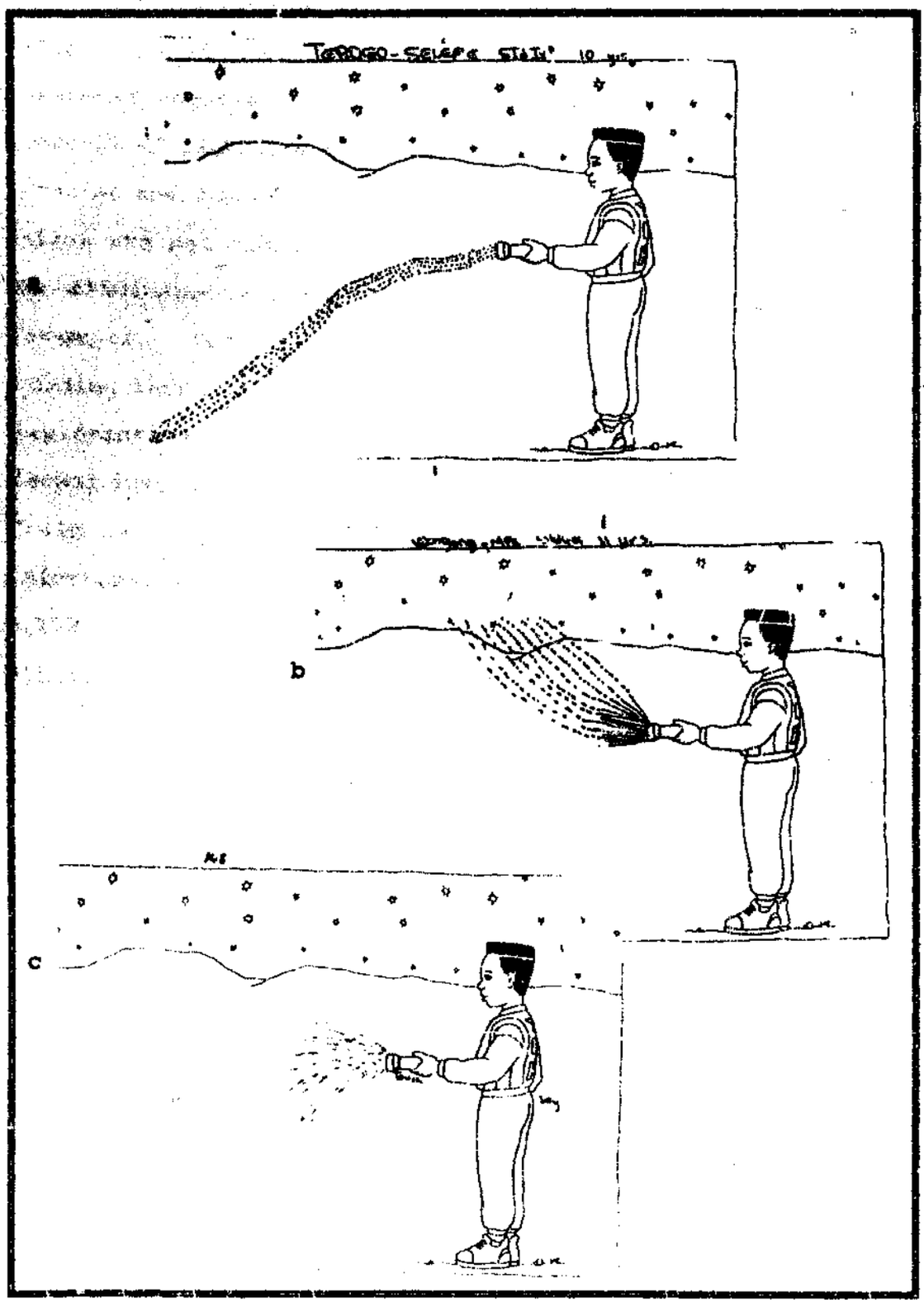
4.6 THE BOY HOLDING A TORCH

In this question copies of pages showing a poster in which a boy is holding a torch in his hand horizontally were distributed to respondents, who were then asked to provide a drawing which shows where the light from the torch goes.

This was aimed at checking on some of the misconceptions the respondents had in connection with the distance that light could travel, or the direction of light from the torch. Again different responses were given. Some of the drawings are indicated in Figure 4.8 below.

a. Light not travelling to far distance from the source.
b. light going in different directions (up and down)
c. Other different characters of drawings.

Figure 4.8 Light rays from the torch



4.7 SUMMARY

From the discussion of results obtained from the diagnostic tests, it is clear that both the pre-service and in-service teachers together with the pupils have similar ideas about the concept of light despite their difference in age and experience. Most of their pre-conception regarding vision and propagation of light are not compatible to those of a scientist. They need to be eliminated and be replaced by the scientifically correct concepts, since both pupils and teachers cannot comprehend when holding these misconceptions. Therefore there is a hope that by implementing resource material such as the MMP coupled with some formal instruction, misconceptions regarding the concept of light could be alleviated and then proper learning will take place. Unfortunately as was already indicated in sections 4.1.3 and 4.1.4 the formal implementation stage could not be reached. Ultimately an arrangement was made with the RADMASTE centre at Wits to conduct a survey with the D.E.T. college lecturers at one of their workshop sessions.

CHAPTER 5

SURVEY CONDUCTED AT WORKSHOP AT RADMASTE

Eight months after the disappointing limited or non-participation of teachers in the project, due to strike activities described in the previous chapter, the researcher was invited by the RADMASTE centre of the University of Witwatersrand to run a workshop with college lecturers. These workshops are organised twice a year for mathematics and science college lecturers from the DET and former homelands authorities.

5.1 MODIFICATION OF OBJECTIVES OF STUDY

The aim of the study had to be shifted to some sort of evaluation of the MMP with the PTD college lecturers teaching science. The workshop focused on:

- establishing what the attitude of both pupils and pre-service teachers towards the MMP might be.
- the interrelation of the various sections of the MMP (e.g comic video,workbooks etc.) with each other and the package as a whole.
- the extent to which certain specific sections of the MMP might stand independently of each other.
- the effect that the MMP might have on the conceptual change of both pre-service teachers and pupils in their learning of the concept of light
- the advantages and disadvantages of using the MMP.

5.2 WORKSHOP PROCESS

The workshop held in February 1994, started with twenty lecturers attending. Twenty copies of the comic were available. Therefore each lecturer had a chance to read the story at his/her own pace. Forty minutes were allocated for the reading of the comic. The lecturers were requested to read with a critical eye for constructive criticism of the package later. They were divided into four groups.

To save time the lecturers were advised to read the comic from different sections; i.e. one group was asked to start reading from the beginning of the comic up to the end, another group had to start with a different section such as "Science is fun", "The spider's place", etc. and read through to the end and then continue until they reach their initial starting point. This strategy aimed at ensuring that in case forty minutes elapsed before some lecturers had completed reading at least the whole comic would have been read.

During the comic reading sessions five lecturers decided to leave the workshop (one by one). When the comic reading was over, the video was projected so as to show the same story on a film screen. The facilities were of a high standard and the hall was darkened: the film was very clear and the sound very good.

At the beginning the hall was very quiet but later on one could hear the lecturers laughing and giggling at some of the events

occurring in the video. At the end of the show some lecturers jokingly requested a replay. Due to less time allocated for this activity a full replay of the video was not possible.

5.3 LECTURERS' PERCEPTION OF THE MMP

Many lecturers saw the MMP as a 'very important tool' which could be used in introducing and teaching the concept of light. They keenly expressed their wish to take the package back to their respective institutions. Some were prepared to pay for the package. Unfortunately, the researcher could not offer anything at that moment except to make them some copies of the activities which occur at the back of the comic. They were told that Hand Spring would be notified of their feelings about the package and a response would be forthcoming during the course of the year. Each lecturer was asked to supply the researcher with his/her name and postal address so that, in case any positive response was achieved, they could be contacted.

5.4 QUESTIONNAIRE AND THE LECTURERS' RESPONSES

After reading the comic and watching the video, the lecturers were requested to complete a questionnaire individually and then discuss some of the questions appearing in it, and then give their own opinions on what they thought of the MMP.

Unfortunately not all lecturers were able to complete the questionnaire in the time available. Some lecturers left some

questions unanswered. One lecturer from each group was requested to discuss the outcome of their group discussion in relation to some of the questions and opinions raised in the questionnaire.

5.4.1 Responses.

5.4.1.1 Questionnaire

This questionnaire (see appendix A) consists of questions related to the image formation in four optical instruments i.e. converging lens (questions 1,2 & 5), plane mirror (questions 3 & 6), concave mirror (question 7) and a glass prism (question 4) and an opinionnaire aimed at establishing the attitudes of the lecturers and their projections about the possible views of primary school student teachers and pupils towards the MMP.

The researcher was interested in finding out the lecturers' reasoning while answering the questions related to image formation in these instruments. Their approach to the problems would quite clearly reflect how they could assist their students in the teaching of the concept of light. Furthermore, these problems were seen by the researcher as a form of encouragement to both lecturers and pre-service teachers to develop a clear understanding of various issues regarding light. In the researcher's opinion it would be much easier for one to teach a concept and to realise the problems experienced by pupils or learners, if teachers had a better understanding of both the content and the application of logical thinking principles

required for problem-solving.

5.4.1.2 Linking the optical questions with the MMP

The content of the MMP is introductory information on the nature of light, which then provides a basis from which other concepts can be introduced. The concepts introduced by the main theme of the MMP are the rectilinear propagation and reflection of light, building up towards an introduction of the idea of refraction. The researcher believes that for teachers to handle these topics of light confidently and logically, they should not only understand the limited information contained in the MMP, but must also have expanded knowledge on other topics such as image formation, not only with plane mirrors as shown in the MMP, but also with lenses. Although geometrical optics is not part of the primary school syllabus, teachers must have deeper knowledge than the level at which they are teaching. This is why it was felt that some questions on geometric optics were necessary in this research instrument.

Unless teachers can handle apparatus such as mirrors, lenses, glass prisms and blocks, which are used in the teaching of concepts related to reflection, refraction and image formation, there is the definite possibility of them being trapped in the less meaningful part of the entertainment in the story and losing the more important conceptual principles of optics that are being introduced. It is very important to make the teachers aware and well-informed of all key issues regarding the subject he/she is

supposed to teach; in this case it is done by coupling the first section of the questionnaire with either diagnostic questions or the comment statements regarding the MMP.

5.5 RESULTS AND DISCUSSION

The questionnaire items were designed to test the subjects' views on a number of specific aspects of light. All the questions are addressed separately below.

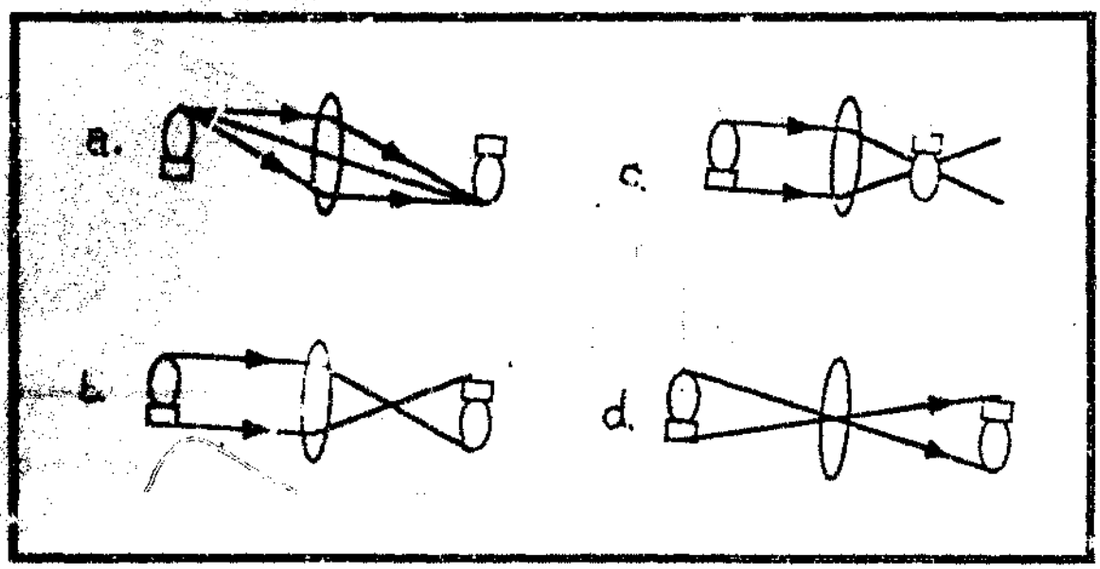
5.5.1 Converging lens

When dealing with a converging lens it might be convenient to consider a single representative point on the bulb facing the lens. A divergent flux of light emitted from this point passes through the converging lens and is then converged to another point on the other side of the lens called the image point. This type of image point is called the real image point, because it is formed by light actually converging to a point. Diagram "a" in Figure 5.1 represents the correct image formation when using a convex lens.

The important feature of diagram (a) is that it shows more than one ray diverging from a point on the bulb, and then, on the other side of the lens, converging to the unique image point. It should be noted that the diagrams appearing in Figure 5.1 show light going through the lens and changing direction in the middle of the lens. However, in the real lens, light will change

direction when entering the front surface of the lens and again when leaving the back of the surface of the lens. For convenience, when drawing ray diagrams, only one change of direction is shown. Sometimes the lens is replaced by a vertical line with small symbols at the top and bottom of the line to indicate it represents a converging lens.

Figure 5.1 Converging lens test



The converging lens question was included in both questions 1 and 5. The questions were as follows:

Question

Which type of lens in Figure 5.2 is responsible for the image formed on the screen?

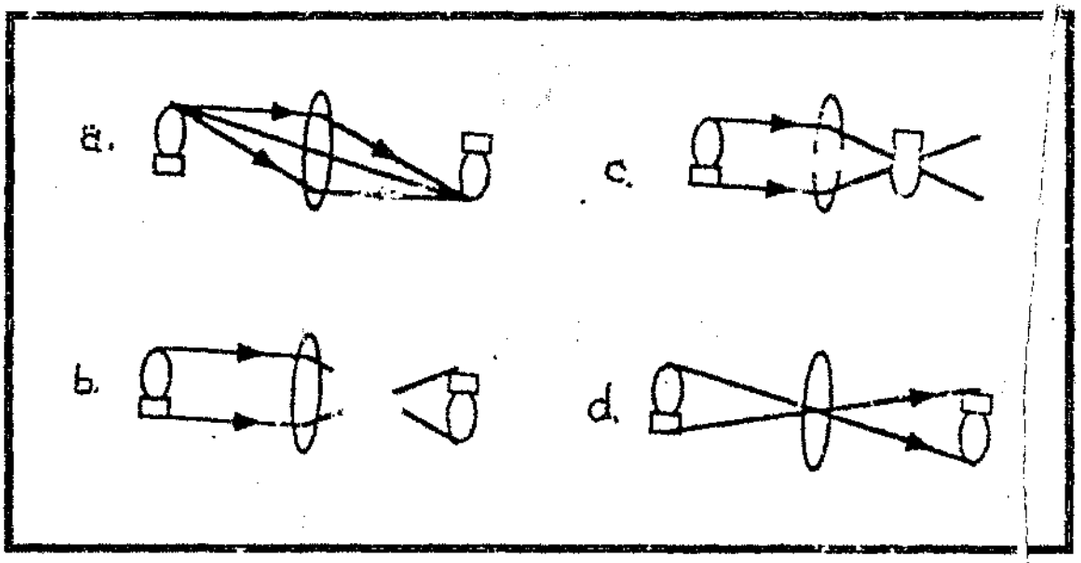
Question 5:

1. Mark with a tick the correct ray diagram from Figure 5.1.

2. Give reason/s why you gave your answer in 1 above.

direction when entering the front surface of the lens and again when leaving the back of the surface of the lens. For convenience, when drawing ray diagrams, only one change of direction is shown. Sometimes the lens is replaced by a vertical line with small symbols at the top and bottom of the line to indicate it represents a converging lens.

Figure 5.1 Converging lens test



The converging lens question was included in both questions 1 and 5. The questions were as follows:

Question 1:

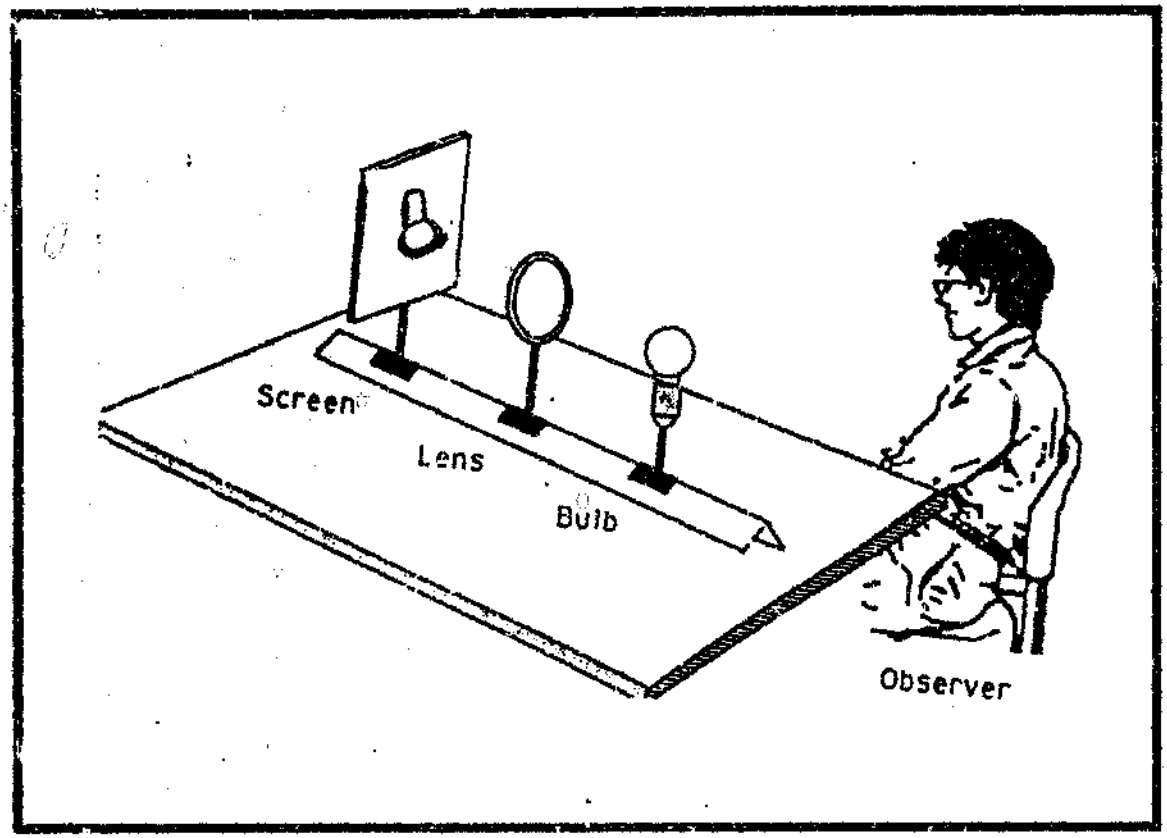
Which type of lens in Figure 5.2 is responsible for the image formed on the screen?

Question 5:

1. Mark with a tick the correct ray diagram from Figure 5.1.

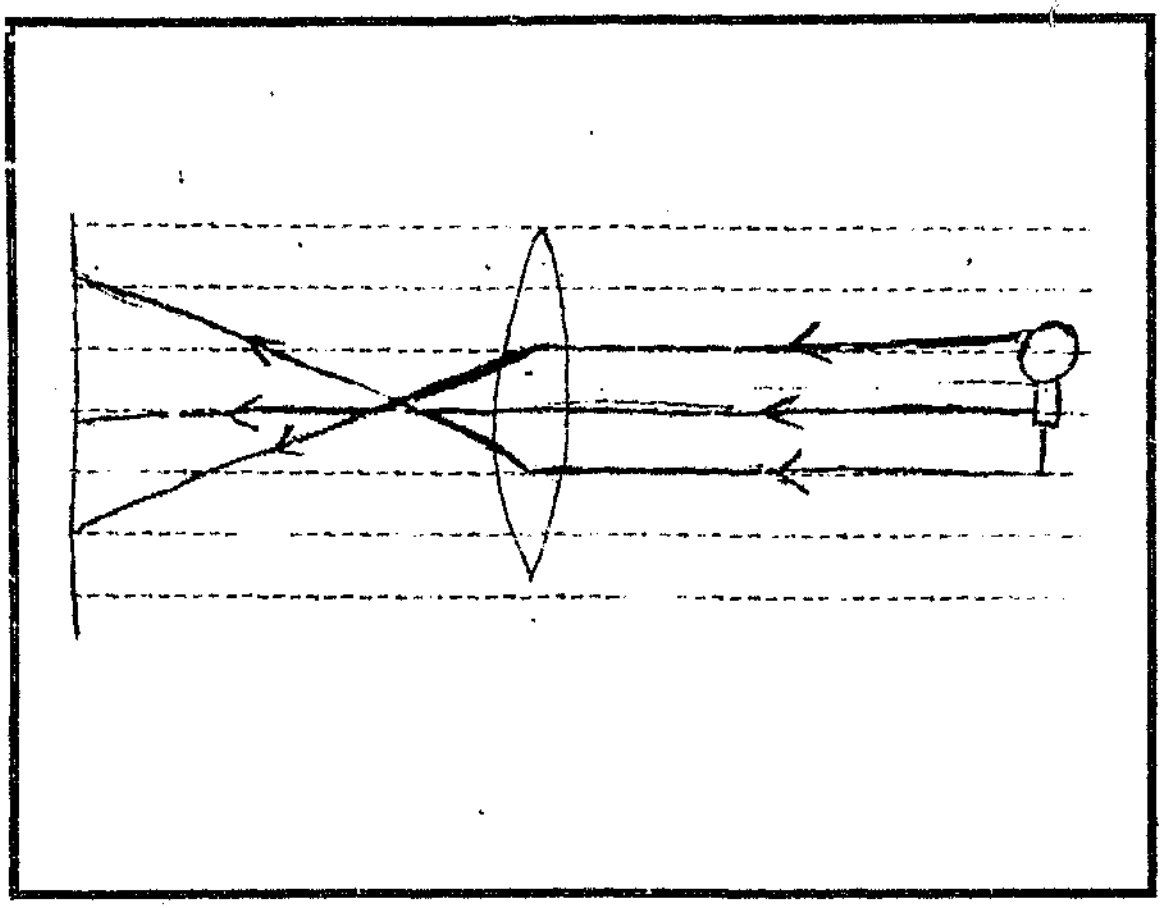
2. Give reason/s why you gave your answer in 1 above.

Fig.5.2 Identification of the type of lens



Question 1 intended to ask for an explanation for the formation of an inverted image by the converging lens on the screen. All the respondents (lecturers) except one, gave verbal explanations. (see Appendix C for further information). Lecturer D gave an answer in the form of the optical drawing of Figure 5.3. His answer is not different from diagram "b" of Figure 5.1. This diagram is a correct representation of the behaviour of light, since light does travel along the directions represented by the light rays. However, the diagram is an incomplete representation of the image formation process, a fact clearly indicated by lecturer C (this will be explained below).

Figure 5.3 A ray diagram drawn by lecturer D



This answer does not represent an important aspect of how the image of the object point is formed, i.e. that light diverging from an object point is made by the lens to converge to a corresponding unique image point. A single light ray drawn from an object point, through the lens, to an image point does not represent a divergent flux of light leaving the object, nor does it represent a convergent flux going to the image point. In addition, such a single ray diagram does not show the uniqueness of the image point.*[1]

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[1]* If one could have had enough chance to interview the respondents, one could have verified this issue by asking the respondents several questions relating to their verification of the image point.

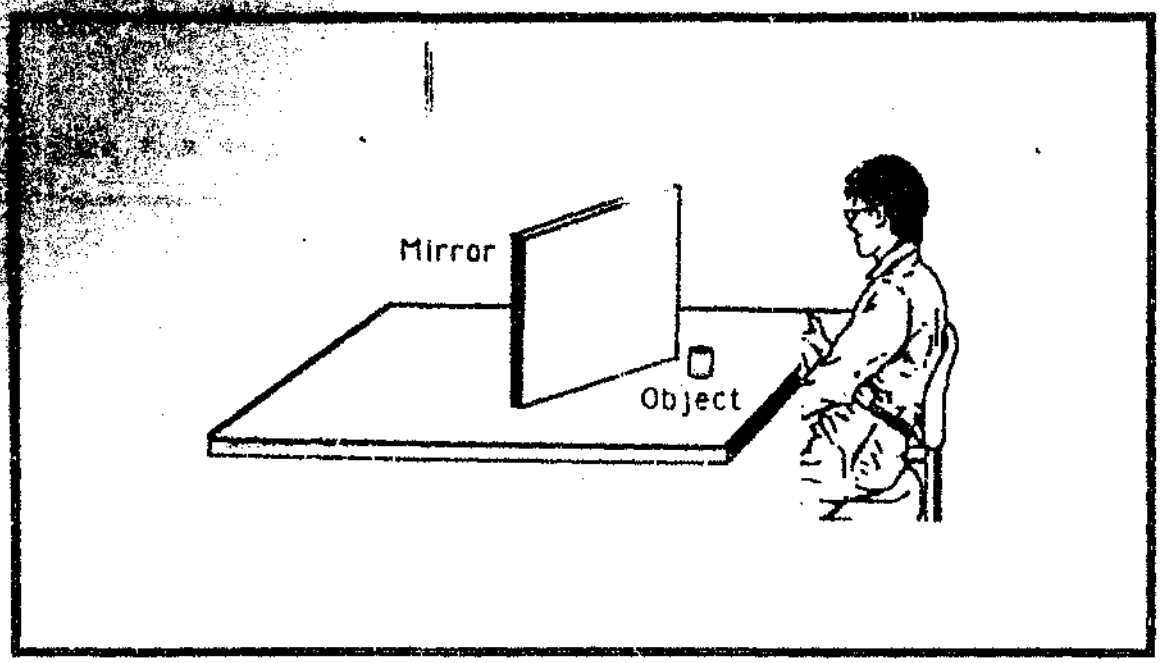
Looking at the verbal responses of lecturers A to I, it appears that several concepts regarding light are well known, e.g. *Light ray travels in a straight line, a ray diagram formed by a convex lens result in an inverted image, light rays passing through a convex lens are refracted convergently, convex lens result in a real and inverted image,* etc. But the significant aspect of how the image of an object point is formed is not clearly represented. It is only when looking at the responses of question 5 that lecturers C and H have a clear idea of the formation of an image from an object point. Lecturer H's reason for choosing option 'a' is: *at least two rays from a particular point have to intersect at a point to show where the sharp image will be formed. Options b, c, and d illustrate different properties of a convex lens, but does not fix the image. In 'c' the rays are brought to a focus point, so no extended image can be formed there.* Lecturer C applied the rules of optics to get to the answer, which is of course correct. She applied the elimination rule as well, this is why she indicates that *in 'c' image cannot form at the focal point, 'd' image cannot form only from light rays that pass through the optical centre of the lens and 'b' acceptable, but incomplete.*

Several lecturers obtained the correct answers either by guessing (e.g. lecturer B) or intuitively knowing the answer, like lecturer A and others, who simply indicated they knew the answer to be simply as it was put forth.

5.5.2 Plane mirror

Two questions were asked in this regard, i.e. questions 3 and 6. A drawing of a plane mirror with an object placed in front of the mirror was supplied and the respondents were asked whether an observer sitting in front of the mirror would be able to see the image in front of the mirror. If he could see it then they should draw the position of the image and if he could not see the image then they should explain why he couldn't see it. This is illustrated in figure 5.4 below.

Figure 5.4 First plane mirror problem



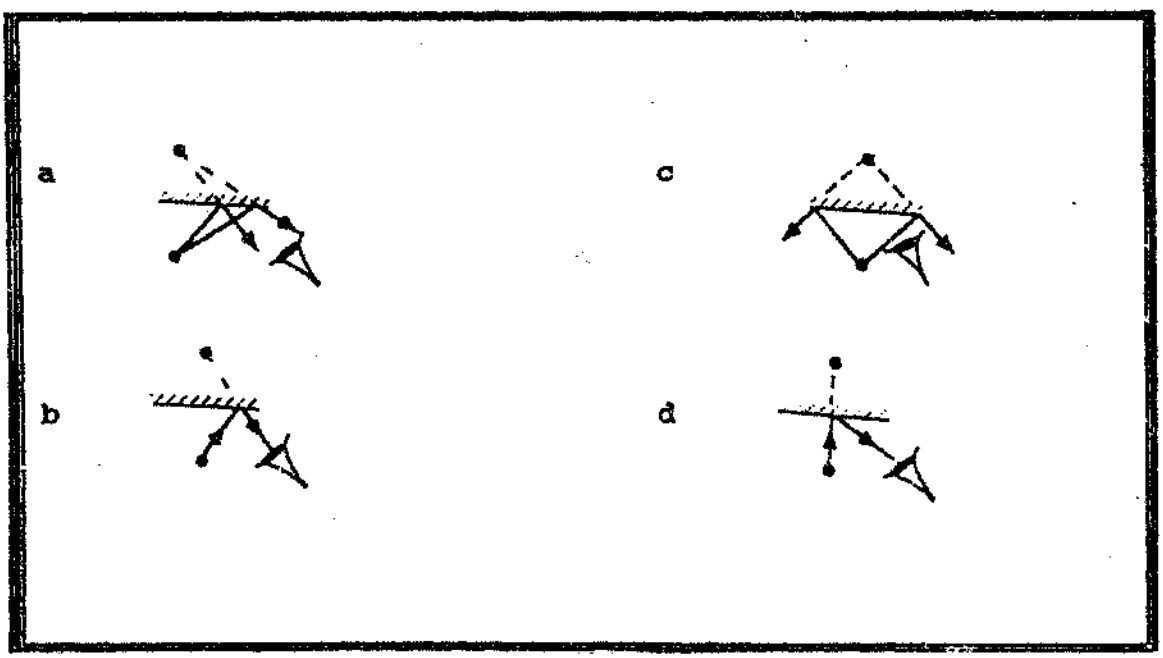
Only four out of nine respondents correctly indicated that the observer could see the image of the object. All respondents including those who answered correctly did not attempt to draw any ray diagrams. The reasons given for not seeing the image by the observer are mainly that light from the object will be

reflected away from him.

The main problem in this regard could be the picture itself. Perhaps the question would have been much clearer if some plane mirrors and objects were made available so that respondents could act as observers and then draw some ray diagrams for the image formation in the mirror.

The same task was asked in question 6 in a different manner. Different optical drawings were supplied, and respondents were asked to tick the correct ray diagram and explain how they had arrived at their answers. This is illustrated in Figure 5.5 below.

Figure 5.5 Second plane mirror problem



All respondents ticked the correct ray diagram. Different explanations for their choice of answers were however given (see

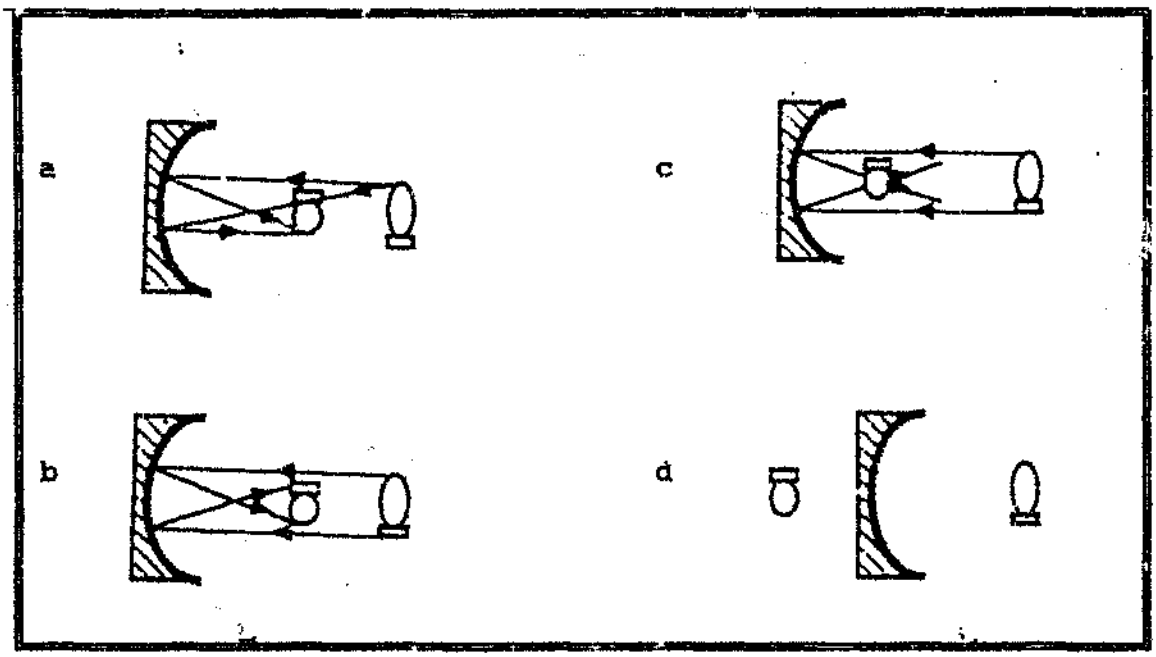
Appendix C for further information). These are for example: Lecturer A: *Recall textbook knowledge*, Lecturer B: *I guessed*, and no reasons in some cases. Lecturer D indicates reason as a mere *angle of incidence = angle of reflection*. No lecturers could explain satisfactorily how the image position was determined by the position of the object and the law of reflection. The researcher suspects this is the reason why none of them attempted to draw any ray diagrams in answering question 3.

A mirror has the property of reflecting incident light in such a way that the angle of incidence equals the angle of reflection, which is in agreement with the reason given by lecturer D above. Again for the plain mirror a divergent flux of light from each point on the object goes to the plain mirror, reflects as divergent flux of light, and then enters the eye of the observer, who perceives it to have originated at the image point behind the mirror.

This point is called the *virtual image point*, and is located the same perpendicular distance behind the mirror surface as the object is in front. Diagram 1 in Figure 5.5 is the correct ray diagram representing the process of image formation with a plane mirror and observer's eye.

5.5.3 Concave mirror

Figure 5.6 Image formation by concave mirror



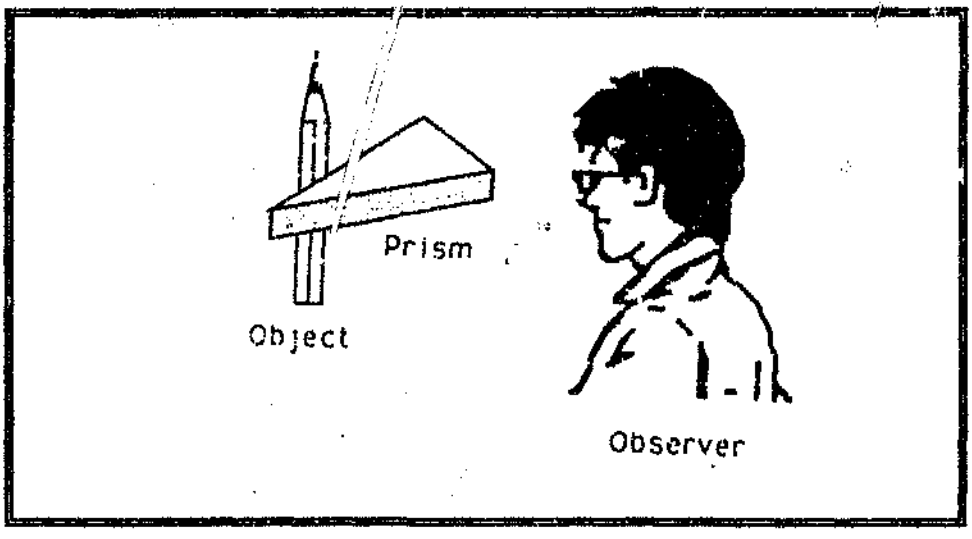
This is based on the information illustrated in Figure 5.6 above. Only one out of nine respondents managed to tick the correct answer (refer to appendix 3 for further responses). This is lecturer H. His reason for the answer is *two lines from one point used to find position of the image*. This task proved to be much more unfamiliar to most respondents. One of the reasons might be that most of the PTD syllabus deals only with plane mirrors and concave and convex lenses. But lecturer H has shown that some mastery of some basic simple logic in dealing with geometrical optics can assist in solving even some unfamiliar problems.

The explanation for this task is mostly related to the explanation of the converging lens task. In both cases the divergent flux of light leaving a point on the bulb is made to

converge to a real image point. Diagram 'a' in Figure 5.6 is the correct answer. It shows rays representing light diverging from a point on the bulb, reflecting from the mirror, and converging to an image point. Diagrams 'b' and 'c' are similar in that they both show two rays going from the top to bottom of the bulb directly to the mirror.

5.5.4 Glass prism

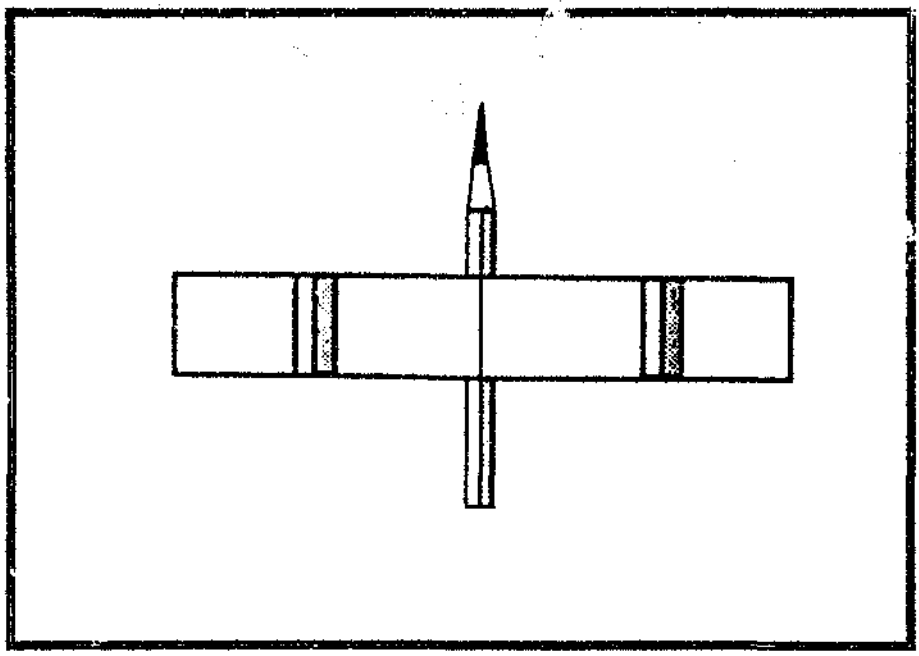
Figure 5.7 A man viewing a pencil through a glass prism



The lecturers were asked to draw what the man observes as he views the pencil through a glass prism as illustrated in Figure 5.7, and then explain what happens to the light as the image he sees is being formed. Unfortunately, this task proved to be very difficult for all participants. Perhaps it could have worked better if the question was asked differently, by supplying the lecturers with the real equipment and asking them to draw a ray diagram of what they observe.

This phenomenon could be understood when one realises that a divergent flux of light goes from a point on the object (in this case, pencil) to the long face of the prism. Upon entering the prism, and again upon leaving, the light gets refracted or changes direction. The divergent flux of light exiting from the prism then enters the observer's eye and is perceived to have originated from another, the virtual image point. Because the pencil is placed in line with the apex angle of the prism, the divergent flux of light originating from the single object point separates into two divergent fluxes when exiting from the prism. Each of them will enter the eye, apparently originating from two different points, which accounts for the observation of the two displaced images illustrated in Figure 5.8 below.

Figure 5.8 Displaced images formed by glass prism



5.5.5 Responses related to the MMP

The basic things the researcher felt were important to look at in designing the opinionnaire were to find out about:

(a) Both pupils' and teachers' attitudes towards the MMP.

(b) The interdependance of the various components of the MMP with each other, and the interaction between the MMP and other more traditional teaching strategies.

(c) The effect that the media could have on the conceptual change of both pupils and pre-service teachers in their concept of light.

(d) The usefulness (advantages) and disadvantages the media might have on the learning of the pupils.

From interacting with the pupils in different schools, it has been apparent that they were interested in, and liked participating in, all the media activities conducted by the researcher. Their teachers also showed a considerable interest. This has been confirmed above (section 1.3, paragraph 1.3.3), we mentioned that although it was not the aim of the researcher to involve the in-service teachers in these activities, they nevertheless showed a high level of interest and participation.

Although it was never possible for the researcher to give comics to the pupils, or to show a video at schools, pupils could quickly recognise characters such as Jay, Ayanda and Frankie whom they have seen from the activities of shining light from the sun roof on Frankie.

Pupils were delighted to hear that they were going to read the comic book and learn more from it. They were happier and more interested when they were told they would also watch the video. This attitude was also shown by lecturers after reading the comic and watching the video. Most of them requested a replay, while others passed some comments like they liked "the music played by Jay", etc. Most, if not all lecturers wanted to have the media for their own institutions. Others asked to be allowed to purchase the media if possible. All of this indicates how positive the attitudes are of those exposed to the MMP.

When asked to comment with regard to the stimulation of pupils' interest in the popularising of science, some of the lecturers said:

A. *Make science come alive again. Pupils realize that every thing is full of science.*

B. *Pupils' interest is stimulated by viewing the video unlike where you start by asking questions in a lesson*

C. *Contextual learning - science is fun; science as useful knowledge - science in relation to peer group interests all aid in popularising of science.*

D. *Pupils would/should be captivated by puppets and fascination of spooks etc.*

F. *It is very stimulating and hence can be used for setting the stage (introduction).*

H. *Very good. Reinforcing the notion that science is fun and important.*

The comments above indicate how stimulating this media is; and

how popular science could be by using media of this sort.

The MMP is seen as something which could encourage children to ask questions about natural concepts related to light. Some lecturers indicate that the counts done by Jay, Ayanda and Frankie after the shining of the lightning might "trigger" questions about the distance and speed of light from the source; and if such questions are asked, they make conditions favourable for the teacher to introduce group discussion. This would make pupils talk about the subject, and therefore pupils would be encouraged towards:

- independent critical thinking
- helpfulness to each other i.e. team work or co-operative learning.
- appreciation of learning for 'themselves', and not simply learning for exams or tests.

The MMP is seen to make science fun and an adventure, as the pupils can relate to characters, and apply some little scientific "trick" learned through the media to solve their own day to day problems. Work-sheets also refer back to incidents in the video, and this helps to keep pupils on track, and encourage them to discuss issues. Lecturers F and G however emphasise that for the media to make science fun and an adventure it should be used properly and with understanding i.e. it should be *stressed to students/pupils that they should watch the video critically and report back on their findings. Otherwise pupils will concentrate*

on the less important aspect of the video, such as the simple entertainment value.

If pupils could relate to the way the three characters solved their problems, then through this media they will be encouraged to learn by doing and solving problems confidently. All lecturers agree that with the help of the MMP the pupils could learn how to solve problems by themselves. One lecturer indicates that: *The story line is about how the characters solved the problems of light source to help them see how Frankie was trapped - this helps to focus on how in fact we use problem-solving in our daily lives*. Therefore as long as pupils work together and co-operate in groups they will always find solutions to their normal day to day scientifically related problems.

On the question of language, different opinions arose. Lecturer G was not sure that the MMP could act as a device for developing language comprehension since he feels that *the video has a language problem of its own in that some of the characters talk too fast*. The same concern was raised by lecturer C: *However I did find it difficult to follow the dialogue in several occasions because the words of the characters were swallowed. Perhaps programme developers would take cognisance of this. Perhaps the characters spoke too fast, especially Spider*.
But she acknowledged that the MMP could be implemented widely across the curriculum.

Some lecturers argued that the language should be maintained as

it is; so that the pupils should learn it while it is being spoken fluently and at the normal speed, because when the child learns a language she or he "picks" it up while it is being spoken with its natural speed and pronunciation. Some lecturers indicated that pupils could learn more language comprehension from this package. They felt that teachers who use it should be encouraged to apply the principle of language across the curriculum.

All the lecturers who responded see the media as an instrument to bring about the possibility of helping pupils to observe, predict and test their ideas. This is viewed in the light of the way in which the three characters approach their problems. They observed how their natural environment behaves, and they came up with suggestions as to how they could react to it and then tested their ideas by putting their thoughts into action e.g. when Ayanda indicated that light could lose some energy and fall to the ground; this idea was put to test by Jay by later flashing the light into her eyes proving her wrong, an indication that light travels continuously unless obstructed.

The MMP also makes pupils get actively involved in scientific activities instead of them learning facts in parrot fashion. This is confirmed in lecturer C's words that ..... *especially when video and comic are used in conjunction with work-sheets. Learning in the context of situations which pupils relate too also reinforce learning from experience.*

The college lecturers had a heated debate on the best way of using the media. Lecturers A, B and their groups felt it would best be used if some discussions about light were done before showing the video, followed by work-sheets. Some lecturers didn't indicate how they could implement the MMP but they simply said *use it in conjunction with the English teacher*, it could be used *as introduction to the lesson* etc.

Lecturer C pointed out that *the video could be shown as an introduction to the topi This could be followed by the discussion of the characters after viewing. Follow up comic group reading dwelling on central problem - light and reflection. This should be followed by work-sheets. This could make an interesting, well thought-out lesson which is characterised by some logical thinking.*

On the question of the relationship of the comic with the video, all lecturers have basically seen these as complementing and reinforcing each other. Each is seen to be playing its particular important role; for example the comic *helps to make things more clearer in case there is any thing you wouldn't have understood in the video*. The comic is seen as explaining events in the video step by step and it could offer pupils a chance to read at their own pace and understand the story well. Another lecturer sees the comic as the illustrated record of the video which helps to reinforce the language and the central concept of light.

Almost all lecturers view both the video and comic as one package

and working together. None could replace the other; instead they reinforce each other. They emphasise that the two must be used in conjunction with the work-sheets. The idea of keeping the MMP as a package (and not as its separate components) is highly recommended.

The MMP, especially the video, must be used with caution. Unless it is used properly, with good planning and control, and is incorporated with the work-sheets, there is a great possibility that the entertainment value could override meaningful learning.

Concerning the development of the light concept, the media is seen as focusing on the need to teach pupils in the context of their experience. The media highlights the importance of relating to peer group interests.

CHAPTER 6

CONCLUSIONS

6.1 INTRODUCTION

Teaching a child is not like simply drawing on a blank slate. A variety of things have already been drawn on the child's mind by everyday experiences. So we should not simply take advantage of children's scientifically compatible conceptions and overlook the negative role played by the pupils' pre- or alternative conceptions which might prevail in these compatible conceptions.

The pupils' pre-conceptions need to be eliminated and be replaced by scientifically correct conceptions. However, scientific concepts are difficult for pupils to learn when they already have interfering pre- or misconceptions. Students or pupils with these misconceptions do not comprehend, or else they misinterpret new information when it is organized according to the scientifically acceptable manner, so learning cannot occur, and the replacement of students' pre-conceptions by scientifically correct conceptions will not take place.

6.2 FINDINGS

6.2.1 Diagnostic test

In almost all Figures drawn by the respondents many responses of pre-service teachers, in-service teachers and pupils are similar. The following are some of the misconceptions observed among the

subjects:

- Vision as a shower of light
- Vision as an active looking process
- Shiny objects are the only ones that reflect light
- A belief that light travels for short distances
- Lack of knowledge that light travels in straight lines
- A veil thrown over the observers to aid their vision

questionnaire

questionnaire the following were observed about

- Most of them had a correct idea about the representation of light in terms of the direction in which light travels
- Many had an incomplete conception of the image formation process i.e. light diverging from an object point is made by the lens to converge to a corresponding unique image point
- They had knowledge of some aspects related to the behaviour of light e.g. "light travels in straight lines, convex lens form real and inverted images, etc.
- They are unable to clearly represent how the image point is formed
- They had serious problems with concave mirrors and prisms

6.2.3 Comment statements

- All subjects have shown positive attitudes. The whole MMP was seen as exciting and interesting. It has the potential of being a good media which could be used in the new teaching styles
- All the parts of the MMP are seen as complementing each other. It could be easy to implement if the whole package is used. The comic and activities can still be used alone where the video facilities are not available.
- The MMP can change the conception of the learners and users while it involves them in activities which make them solve problems. Again it makes them (subjects) apply strategies which encourage them to test their ideas. As soon as the subject realises that his or her ideas are not effective, he or she will abandon the idea and change to the scientifically acceptable one.
- The MMP makes the learner learn while enjoying the story.

6.3 IMPLICATIONS

6.3.1 Diagnostic test

If not taken care of, the identified misconceptions could have the following consequences on teaching:

- teaching and learning progress could be retarded .
- teaching to pupils will not be effective.

- learning and understanding will not take place.

Therefore the above will have a negative effect on the attitudes of both teachers and pupils towards science. If they are identified and addressed, then positive results are envisaged.

6.3.2 Questionnaire

Inadequate representation of image formation might cause the students to:

- encourage guess work and rote learning
- be unable to understand geometrical optics
- have little or no confidence in teaching the topic in particular

6.3.3 Comment statements

This study and the production of this package has indicated that should other topics which are part of the syllabus be selected and prepared in this form of an MMP, learning could improve quite substantially. e.g. learning would be a fun for pupils i.e.

- the material manages to attract the people's interest.
- it also has the ability to motivate and encourage pupils to actively participate in their learning activities simply because:

a. it is a new method in itself
b. the bright colours are attractive to pupils
c. it provides time to do some activities, which used to be a

very rare thing in our classroom.

d. music, activity, and action in the video enliven the whole learning activity. Entertainment makes pupils learn while enjoying. It gives children a different view of learning.

Lastly, maximum efficiency in the pupils' learning could be attained by using the package as whole

6.4 RECOMMENDATIONS

6.4.1 In order to implement the MMP effectively, teachers need to be trained and empowered through the attainement of knowledge.

6.4.2 Teachers should always identify misconceptions through tests while teaching.

6.4.3 Activities found in the MMP should be implemented to eliminate misconceptions.

6.4.5 The MMP should only be introduced to the classroom as an additional resource and not as a textbook.

6.4.6 The MMP may be used in both English and Science lessons.

6.4.7 A package of this nature should be developed for other topics which are currently taught in primary school classes .

REFERENCES

Akindehin, F. (1988). Effects of instructional package on pre-service science teachers' understanding of the nature of science and acquisition of science related attitudes. Science Education. Vol.72, No.1. pp 73-82.

Bahr, M.A. & Perold, H. (1992) Report of evaluation of the Spider's Place comic as an educational resource in a rural schooling environment. Unpublished evaluation report No.1.

Bahr, M.A. & Perold, H. (1993) Report of evaluation of the Spider's Place comic as an educational resource in a rural schooling environment. Unpublished evaluation report No.2.

Bentley, D. & Watts, M. (1989) Using the role play and drama in science. Alden Press Limited, Oxford.

Bodner, G. (1986) Constructivism: A theory of knowledge. Journal of chemical education. Vol.63, No.63. pp.837-878.

Bradley, J.D., Gerrans, G.C. & Mathee, A.J. (1989). Views of some secondary science teachers and student teachers about chemical bonding. South African Journal of Education. Vol.9, No.4. pp 637-643.

Bruner, J. (1975). Beyond The Information Given. In Entwistle, N. & Hounsell, D. (1975) How Students Learn. University of Lancaster.

Bulman, L. (1985). Teaching language and study skills in secondary science. Heinemann Educational. London.

Carter, K. (1993). The place of story in the study of teaching and teacher education. Educational Research. Vol.22, No.1. pp 5-12.

Clement, J., Brown, D.E. & Zietsman, A. (1989). Not all preconceptions are misconceptions: finding 'anchoring conceptions' for grounding instruction on students' intuitions. INT.J.SCI.EDUC. Vol.11, SPECIAL ISSUE, pp 554-565.

De Lange, J.P. (1981). Report of the working committee:teaching of natural sciences, mathematics and technical subjects. Pretoria: Human Science Research council.

Driver, R. & Er[illegible], G. (1983). Theories in action: some theoretical and empirical issues in the study of students' conceptual frame works in science. Studies in science education. Vol.10, pp 37-60

Driver, R., Guesne, E. & Tiberghien, A. (1985). Light. Children's ideas in science. Open University Press.

Elbaz,F. (1991). Research on teacher's knowledge: the evolution of a discourse. Journal of Curriculum Studies. Vol.23, No.1. pp 1-19.

Galili, I., Bendall, S. & Goldberg, F. (1993). The effects of prior knowledge and the instruction on understanding images. J. of Research in Science Teaching Vol.30, No.3 pp 271-301.

Gerrans, G. (1989). Teaching and learning in science at university: Time for a paradigm shift. South African Journal of Science. Vol.85, No.9. pp 565-567.

Goldberg, F., Bendal, S. & Galili, I. (1991). Lenses, pinholes, screens and the eye. The Physics Teacher. Vol.29, No.4. PP 221-224.

Hewson, M.G. (1982). Students' existing knowledge as a factor influencing the acquisition of scientific knowledge. Unpublished Ph.D. thesis. University of Witwatersrand.

Hewson, M.G. & Hewson, P.W. (1983). Effects of instruction using students, prior knowledge and conceptual change strategies on science learning. Journal of Research in Science Teaching. Vol.20, No.8. pp 731-743.

Hewson, P.W. & Hewson, M.G. (1987). Science teachers' conception of teaching: Implication for teacher eduction. INT.J.EDUC. Vol.19, No.4. pp 425-440.

Johns, M.D. (1986). A manual for 3Rs: Reading, Reflecting and reacting. Instructional model, Edit. by Martuza V.R. University of Delaware. pp 9-20.

Jones, B., Perold, H., Bahr, M. A. & Rollnick, M. (1992). Development of multimedia package for higher primary science. Hand spring Primary Science Project (unpublished draft copy).

Joubert, D., Joyce, T. & Cloete, A. (1992). Industry initiative for Technology, Engineering and Science promotion. A paper presented for South Africa beyond 2000. A national consultative forum to promote and demystify mathematics, Science and technology, with a focus on awareness and guidance. 21 - 23 October 1992

Kahn, M. (1993). Building the base. Report on a sector study of science and mathematics education.

Lightman, A. & Sadler, P. (1993). The teacher versus actual student gains. The Physics Teacher. Vol.31, No.2. pp 162-167.

Lucas, K. B. & Dooley, J. H. (1982). "Student teachers'attitudes toward science and science teaching." Journal of Research in Science Teaching. Vol.19, No.9. pp 805-809

Magoon, A. (1977). 'Constructivist approaches in educational research'. Review of research in education. Vol.47, No.4. pp 651-69

Mphahlele, M.K. & Kahn, (1993). The science "vacuum" in people's education: Why? A paper presented at South African Association for Research in Science and Mathematics Education first annual meeting. 28 - 31 January 1993. pp 157-168

Naidoo, P., Brooks, D. & Pillay, A. (1993). Towards the development of the science teacher: A case study at the University of Durban-Westville. South African Association for research in science and mathematics education compilation of papers. (1st annual meeting 28-31 January 1993) pp 11-22.

Oude, N.A. (1991). Teaching and learning difficulties in electrochemistry. Ph.D. Thesis University of Witwatersrand.

Osborne, J.F., Black, P., Meadows, J. & Smith, I. (1993). Young children's (7-11) ideas about light and their development. International Journ[illegible] of science education. Vol.15, No.1. pp 83-93

Pope, M. & Gilbert, J. (1983). Personal Experience and the Construction of Knowledge in Science. Experience and Science. Vol.67, No.2. pp 193-204.

Perold, H. & Bahr M.A. (1993:64). Report on the evaluation of materials comprising the pilot programme. National science education project dealing with preconceptions and problem-solving strategies in primary science. Handspring Trust for Puppetry in Education.

Posner, G.J., Strike, K.A., Hewson, P.W. & Gertzog, W.A. (1982). Accommodation of scientific conception: Towards a theory of conceptual change. Science Education. Vol.66, No.2. pp 211-227.

Spider's place. Handspring Primary Science Programme (PSP). 1992.

Stefanich, G. P. & Kelsey, K. W. (1989). Improving science attitudes of pre-service elementary teachers. Science Education Vol.73, No.2. pp 187-194.

Williams, G., Murray, F. & Poole, S. (1992). Creativity in class room. School Science Review Vol.74, No 267. pp 17.

APPENDIX A

QUESTIONNAIRE CONDUCTED TO TEACHERS AND LECTURERS

Identification No. ----------

Sex ----------

Name of Institution ----------

Course Level/Standard ----------

The purpose of this questionnaire is to find out your views concerning concepts related to light. The answers you supply in this questionnaire will not affect your year mark or examination mark in any way (i.e. you will not be graded on the results obtained from this questionnaire). So, feel free to answer the following questions about "light". The researcher wishes to find out what your ideas about light are.

Please answer every question and supply reasons where requested. For each question indicate your level of confidence by ticking the relevant box.

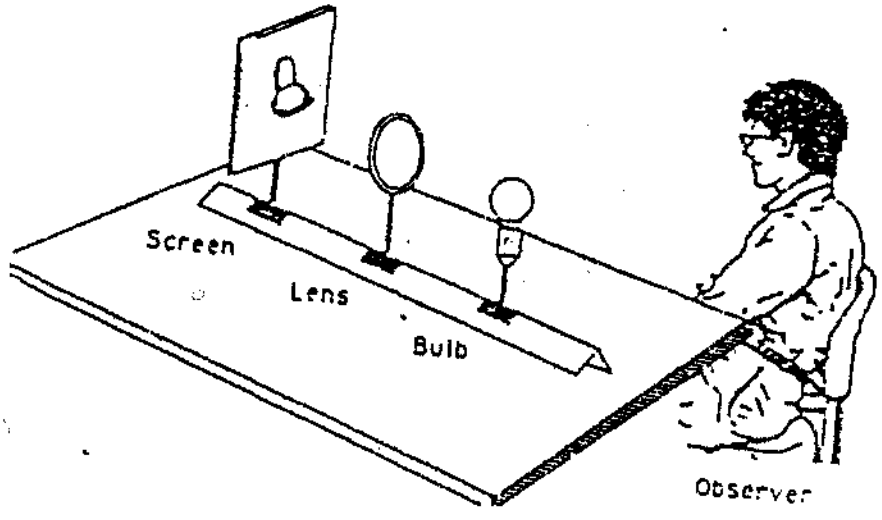
Solutions to the problems will be provided later on, in order to help you clarify own ideas.

In order to make your response meaningful, you are requested not to obtain answers from another student or the lecturer.

QUESTIONNAIRE No.1

QUESTION 1.

Figure 1.

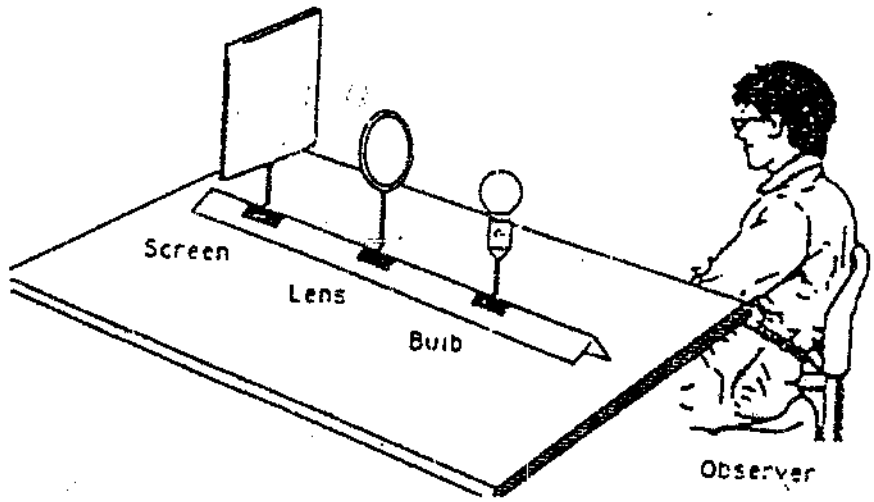


1.1. Which type of lens is responsible for the image formed on the screen in Figure 1? ....

1.2. Explain how you have arrived at your answer

QUESTION 2.

Figure 2.

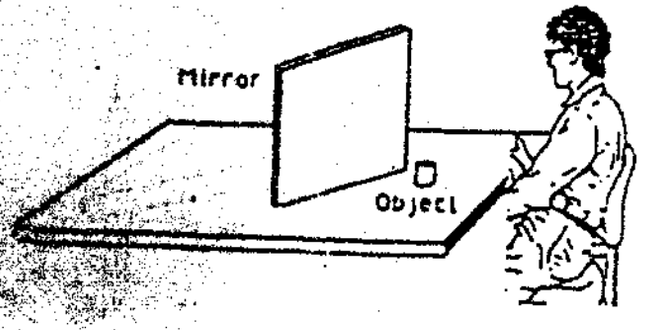


2.1. If the lens drawn in Figure 2 is a convex lens, indicate with a drawing on the screen the type of image formed by this set-up.

2.2. Explain how you have arrived at your answer

QUESTION 3.

Figure 3.



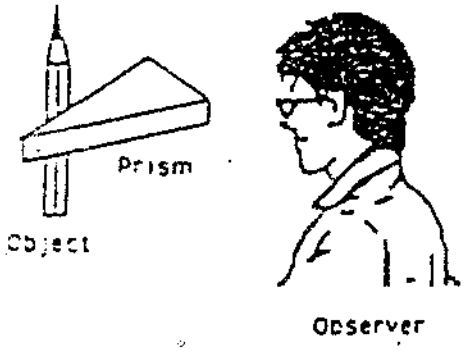
3.1. Can the observer see the image of the object in the mirror in Figure 3? .....

3.2. If your answer is 'yes', then indicate the image and its position by drawing on the surface of the mirror.

3.3. If your answer is 'no', then explain why.

QUESTION 4.

Figure 4.



4.1. Draw what the man observes in Figure 4.

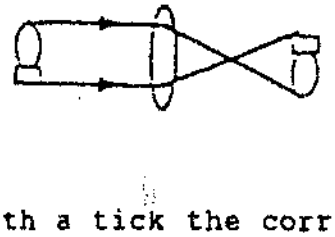
4.2. Explain how you have arrived to your answer

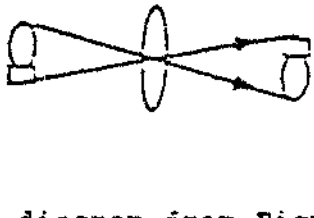
QUESTION 5.

Figure 5.

a. 

c. 

b. 

d. 

5.1. Mark with a tick the correct ray diagram from Figure 5.

5.2. Explain how you have arrived at your answer

QUESTION 6.

Figure 6.

1.



3.



2.



4.



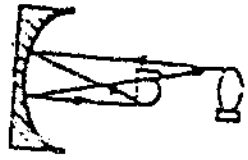
6.1. Tick the correct ray diagram in Figure 6.

6.2. Explain how you have arrived at your answer

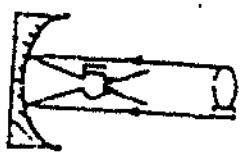
QUESTION 7.

Figure 7.

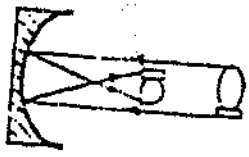
a.



c.



b.



d.



7.1. Tick the correct ray diagram in Figure 7.

7.2. Explain how you have arrived at your answer

APPENDIX B

COMMENT STATEMENTS

The following section requests you to give your opinions concerning the media you have just studied. Please discuss the questions amongst yourselves as a group and give your comprehensive responses both in a written form and in a form of presentation. (A separate sheet of more comments may be attached to the questionnaire)

1. Does the media encourage the children to ask questions about the natural concepts related to light? Yes/No
   Please elaborate.

2. Can the media make science to be fun and adventure? Yes/No
   Please elaborate

3. Can ... media encourage pupils to learn by doing and solve problems confidently? Yes/No
   Please elaborate

4. Can it act as a device for developing language comprehension? Yes/No
   Please elaborate

5. Does it have any possibility in helping the pupils to observe, predict and test their ideas? Yes/No
   Please elaborate

6. Does it make pupils actively involved in science experiences instead of them learning the facts (in a parotic fashion)? Yes/No
   Please elaborate

7. What do you think could be the best way of using this media?
   Please elaborate
   What is your comment with regard to the stimulation of the pupils' interest and the popularising of science?
   Please elaborate

9. What do you think the attitude of both pre-service teachers and primary school children could be towards this media?
   Please elaborate

10. How do you think the comic is related to ...deo?
    Please elaborate

11. What are the advantages of the comic over t... video and vice versa?
    Please elaborate

12. Do you think the comic can be u...d independent of the video or the video independent of the comic? Yes/No
    Please elaborate

13. What do you think are the disadvantages which this media could have on the lea..ing process of the primary school pupils?
Please elaborate

14. What effect do you think this media could have on the development of the light concepts on the primary school teachers?
Please elaborate

APPENDIX C

DIAGNOSTIC TEST

This test was administered to both primary school pupils and pre-service teachers.

1. How light helps us see.

Put up poster of a boy watching the tree and hand out photocopies to each child/teacher.

Q: What is in the picture?
Q: Where does light come from?
Q: Where does sunlight go?
Q: How does the sunlight help the boy to see the tree?

Draw how the sunlight helps the boy to see the tree.

Ask each pupil/teacher to explain what they have drawn.

Problem solving activity.

Place someone (called 'A') behind the door so that no part of him/her is visible.

Q: Can we see 'A' behind the door?
Q: Are we sure that he/she is there?
Q: Why can't we see 'A'?
Q: How does the door stop us from seeing 'A'?

Q: What is the door in the way of?/ What is the door blocking?
Q: So, how do we see?
Q: What can we do to find out how many fingers 'A' is holding up?

Here are the mirrors. Try to use them so that we can see behind the door, and check how many fingers 'A' is holding up.

2. Light travels in straight lines
Hand out photocopies of "still" from video animation sequence.
Explain that the sources of light is via the skylight.

Draw how the two mirrors can be used to shine light on Frankie.

Ask selected children/teachers to explain what they have drawn.

Monitor how the children/teachers tackle this task.

3. Reflection by mirror/reflection off notice board.

Request children/teachers to face a mirror as well as a screen/white board.
Ask volunteers to look in the mirror and then at the board.

Q: Why can you see your face in the mirror, but not on the

screen?

Hand out photocopies of mirror and notice-board.

Q: What is happening in these two drawings?
Q: How does the light help the girl see herself in the mirror?
Q: How does the light help the girl see the notice board?
Q: Why do you see the girl in the mirror but not on the notice-board?

The girl can see herself in the mirror. The girl cannot see herself in the board. Try to show what is happening to the light on your drawing.

4. Misconception: light falls down

Put up poster of a boy holding a torch, then hand out photocopies of same. Show torch and switch it on and off.

Q: Show where the light from the torch goes.

APPENDIX D

COLLEGE LECTURERS' RESPONSES FROM QUESTIONNAIRE (Appendix A):

1. "Which type of lens is responsible for the image formed on the sceen in Figure 1?" Explain how you have arrived at your answer.

A. Light rays travel in straight lines from object to screen through lens. Recall rules learned + apply. (emphasising recall)
B. The image formed is inverted but of the same size with the object. (not explaining how he arrived at the answer)
C. Image is real and inverted
E. 'cause light rays from the concave mirror do not focus on the same point, but can only be traced back and the image formed.
F. The lens converges the rays onto the screen. The size of the image would depend on its distance from the focal length.
G. The inverted image is a result of a ray diagram formed by a convex lens. Refracted convergently.
H. Only convex lenses form real images.
I. Real image formed.

2. "If the lens drawn in Figure 2 is a convex lens, indicate with a drawing on the screen the type of image formed by this set-up." Expliain how you have arrived at your answer.

RESPONSES
A. Recall rules learned
B. When a convex lens is used the image is upright and enlarged.
C. Check from previcus question - perhaps you need to place the object lens and screen in different positions.
D. As previous page.
E. Assuming that the object is on 2f then the image will be formed on 2f' same size and inverted. (same explanation as before)
F. The image will be inverted its size will depend on the position of the bulb from focal point i.e. focal length.
G. Convex lens converges the rays and image is small inverted.
H. Real images are inverted. One has to assume that U, V and F are correct for an image to form.
I. Real images are always inverted.

3. "Can the observer see the image of the object in the mirror in Figure 3? If your answer is 'yes', then indicate the image and its position by drawing on the surface of the mirror. If your answer is 'no', then explain why."

A. Yes. A picture is drawn
B. No. There is no distance between the object and the mirror.
C. Yes. Different to draw in 3-dimension without use of ray diagrams.
D. No. See drawing.
E. Yes. See drawing.
F. Yes. See drawing.
G. No. The angle at which the observer is won't make it possible

for him to see the image in the mirror.
h. No. By having the mirror angled the light from the object is reflected away from the observer.
I. No. Rays from object are reflected to left of observer.

4. "Draw what the man observes in Figure 4. Explain how you have arrived at your answer".

A. No drawing. Refraction of objects depends on angle that observer views the object.
B. He observes that the object is inverted and enlarged. I just guessed.
C. See drawing. Refraction of light rays occurs when light rays pass from the part of line pencil ... through the person.
D. See drawing. Refraction of light.
E. See drawing. Refraction of light rays travels from less dense to more dense.
F. See drawing. Because of the bending of light rays (Refraction)
G. See drawing Glass prisms rays of light are refracted as they enter one medium to the next.
H. See drawing. Observer interprets light to come along a straight line.
I. See drawing. Light refracted by prism the eye sees in straight lines.

5. "Mark with a tick the correct diagram from Figure 5. Explain how you have arrived at your answer."

A. a. I know the answer.
B. a. Guessed.
C. a. (c. Image cannot form at focal point. d. Image cannot be formed only from light rays that pass through the optical centre of the lens. b. Acceptable but incomplete.)
D. b. Light bent as it goes through lens.
E. a. Because the image is formed where the rays meet - and at that point we can only see the tip of the globe because the rays have emerged from the tip of the globe.
F. a. Light will travel in such a manner that it changes direction on entering a new medium. This happens to all the rays except for the one which passes through the focal point.
G. a. The 3 rays follow a correct pattern of a convex lens.
H. a. At least two rays from a particular point have to intersect at a point to show where the sharp image will form. (b), (c) and (d) illustrate different properties of a convex lens but does not fix the image. In (c) the rays are brought to a focus (point) so no extended image can be formed there.
I. a. Rays must meet at a point to show distance from lens.

6. "Mark with a tick the correct diagram from Figure 6. Explain how you have arrived at your answer."

A. 1. Recall textbook knowledge.
B. 1. I guessed.
C. 1. correct. 2. incorrect. 3. rays bypass eye - ray diagram incorrect. 4. Angle no ray.
D. 1. angle of incidence = angle of reflection

E. 1. No explanation.
F. 1. The light rays travel from the object and are reflected by the mirror towards the eye. Because we have a mirror, the image will be cast on the opposite and at the same distance from the object.
G. 1. The rays are drawn correctly because of reflection of these rays.
H. 1. Show arrow heads and labels. 2, 3 shows correct ray reflection and position of image bent not sufficient to find image by observation.
I. 1. Two rays needed to show apparent depth of image in mirror.

7. "Tick the correct ray diagram in Figure 7. Explain how you have arrived at your answer."

A. b. Recall ray diagrams.
B. b. I guessed.
C. b. (a. incomplete. d. Image behind mirror, light rays reflected from mirror. c. Image at focal point.)
D. b. Light reflected onto image at angle = angle at light of concave mirror.
E. c. No d. is out, because the concave mirror does not form an image on the other side, because in the other diagrams i.e. a,b,c; c is correct, because in a & b the image does not form where the rays meet.
F. not attempted
G. c. The concave lens refracts divergently; if the imaginary image formed is traced back , it gives us an inverted image as in c.
H. a. Two lines from one point used to find position of image.
I. Not attempted.

APPENDIX E

RESPONSES FROM THE COMMENT STATEMENTS (Appendix B)

1. Does the media encourage the children to ask questions about the natural concepts related to light?

A. Yes:
i. Lightning counts - trigger questions about distance + speed of lightning from source.
ii. Reflection of light - will ask how + when to try it by themselves.
iii. Reflection of Spider ("Spook") in overall.
iv. The "energy loss" of light (Ayanda) - will ask how/why

B. Yes:
They will ask for explanation about some actions.

C. Yes.
Video is riveting - followed by comic concepts one again emphasised comic & video provide excellent motivation and stimulation. But focus on light concepts only as a small part of total shaw - any immediate focus was on the characters - comments on light incidental.

D. Yes.
Catches interest with real life situation and puppets (excellently put together) and every day situation.

E. Not attempted

F. Yes.
I think it will for example the example mentioned where in one of the participants feels that the light will be too weak and will bounce off.

G. Yes.
The attention of the children will be attracted more by puppets, puppets' actions.

H. Yes.
Yet pupils are told the facts. However the attempt to let the children in the story to solve problems by discussion and investigation should give the pupils some motivation to use a similar approach to solve problems.

I. Not attempted.

2. Can the media make science to be fun and adventure?

A. Yes.
Definitely. relate to their knowledge and on experiences of what they have seen in the bathroom,spooks, window reflections, etc.

B. Yes.
They followed the cat and reached a whole.

C. Yes.
Pupils can relate to characters - work-sheets refer back to incidents in the video, this helps to keep pupils on track and would then encourage the students to discuss issues.

D. Yes.
Spooks are something all children are scared of [illegible]en I felt the hair on my arms standing up when [illegible]ed spooking - effect of music as well.

E. Not attempted.

F. Yes.
Provided it is stressed to the students that they need to watch the video critically and report back on their findings. Otherwise the pupils will concentrate on the less important aspect of the video.

G. Yes.
If used properly and understandably. Especially in cases where there are lack (absence) of apparatuses.

H. Yes.
Children like to hear stories, look TV and read comics.

I. Not attempted.

3. Can the media encourage pupils to learn by doing and solve problems confidently?

A. Yes.
They will try to use a mirror to check underneath a dark shelve in a cupboard etc.

B. Yes.
They use the mirror to reflect light to different corners.

C. Yes.
The story line is about how the characters solved the problem of a light source to help them see how Frankie was trapped - this helps to focus on how in fact we use problem solving in our daily lives.

D. Yes.
If they think & and discuss problems with others they will find a solution.

E. Not attempted.

F. Yes.
If students (pupils) relate to the way the group solved their problem (lifting Frankie) then it will or might help in triggering problem solving skills.

G. Yes. (No elaborations)

H. Yes. (No elaboration)

I. Not attempted.

4. Can it act as a device for developing language comprehension?

A. Yes.
Use across the curriculum for language, geography - comprehension test, etc.

B. Yes.
The English teacher can use it as a comprehension test (English around [across] the curriculum)

C. Yes.
However I did find it difficult to follow the dialogue in several because the words of the characters were "swallowed". Perhaps programme developers would take cognisance of this. Perhaps the characters spoke too fast especially Spider. Invites cross curricular interaction.

D. Yes.
Ayanda said "light bounces off the mirror" & Frankie rejects. Using screw driver to open paint tin referring to 'lever the beam up'.

E. Not attempted.

F. Yes .
If it is used in the programme of language across the curriculum.

G. Not sure.
The video shown has language problem of people talking faster.

H. Yes.
Comic stimulates reading.

I. Not attempted.

5. Does it have any possibility in helping the pupils to observe, predict and test their ideas?

A. Yes.

Predict various ways to get :
i. light in the room (e.g. torch if found or opening shelters if any, use matches, candle etc.)
ii. use another method of lifting the jammed bar
iii. apply sound (various ways) to attract attention.

B. Yes.
When one suggest mirrors can be used they tested it and it worked. They gained much information from the video and they can go and test them.

C. Yes.
If pupils relate to characters they to some extent serve as role models.

D. Pupils could take mirrors outside & try and "pass light through" solid objects - try prove that what they saw in the video is true.

E. Not attempted.

F. Yes.
If they copy the puppets then it can stimulate pupils to observe, predict and test their ideas.

G. Not attempted.

H. Yes.
The are duly shown how the puppets solve problems. The activities are too prescriptive.

I. Not attempted.

6. Does it make pupils actively involved in science experiences instead of them learning the facts (in a parotic fashion)?

A. Yes.
Because they realise science is part of every day activities they learn science without needing to memorise facts, the facts do stick into their minds.

B. Yes.

They learn to be more practical than theoretical.

C. Yes.
Especially if comic and video are used in conjunction with work-sheets.Learning in the context of situations which pupils relate too also reinforce learning from experience.

D. Yes.
Pupils see science in action in everyday situation.

E. Not attempted.

F. Yes.
The video helps them to learn science from different media and not only depend on the textbook for all/any scientific knowledge.

G. Not attempted.

H. At least it is a good starting point.

I. Not attempted.

7. What do you think could be the best way of using this media?

A. Discussion, Show video nationwide and in classroom situation, and do activities afterwards.

B. Get the general knowledge about light. Show them a video. Give them activities to work out.

C. Showing the video as an introduction to the topic. Discussion about the characters after viewing. Follow up nice comic group reading focusing on central problem - light and reflection. Work-sheets interesting - well thought out - logical sequency.

D. This was great but for one simple fact of science (i.e. light travels in straight lines) I think it will be impractically expensive - maybe if put onto TV could reach a lot of views, with a valuable message.

E. Not attempted

F. Use it in conjunction with the English teacher. The science teacher could go further and explain important science concepts.

G. Not attempted.

H. As introduction to the topic.

I. Not attempted.

8. What is your comment with regard to the stimulation of the pupils' interest and the popularising of science?

A. Make science come alive again. Pupils realize that every thing is full of science.

B. Pupils' interest is stimulated by viewing the video unlike where you start by asking questions in a lesson.

C. Contextual learning - science is fun; science as useful knowledge - science in relation to peer group interests all aid in popularising of science.

D. Pupils would /should be captivated by puppets and fascination of spooks etc.

E. Not attempted.

F. It is very stimulating and hence can be used for setting the stage (introduction)

G. Not attempted.

H. Very good. Reinforcing the notion that science is fun and important.

- What do you think the attitude of both pre-service teachers and primary school children could be towards this media?

A. Positive. Children know a lot of things already. Textbooks just pick out certain concepts not related to their own world of experience. Concepts in textbooks are just facts and are exam/question orientated. Video is what pupils (and TV computers) are interested in. No bad things happen (no killing or shooting)

B. It will be positive. The children will be interested by the media and the teachers will enjoy it because the children will be interested and gaining knowledge at the same time.

C. Very positive:
Teachers - viable and easily implemented resource.
Pupils - Concrete, fun experiences.

D. Good but highly unlikely to be found in colleges and schools especially rural schools.

E. Not attempted.

F. It depends on the type of teacher we are looking at. if the teacher promotes rote learning in his class he will see it as a time-consuming exercise. School children are merely dependent on their teacher.

G. Not attempted.

H. Should be positive.

I. Not attempted.

10. How do you think the comic is related to the video?

A. Very good especially for discussion of concepts afterwards. Colourful.

B. The comic explain clearly all the action in the video because some of the words are not clearing the video. The comic explains step by step what is happening in the video.

C. Written illustrated record of video - which helps to reinforce the language and the central concept of light. Value of comic is that it serves to direct the attention to the question of light. The video riveting entertainment which could direct attention away from central concept the useful style.

D. Basically the same.

E. Not attempted.

F. The comic relates well to the video and it helps to make things clearer in case there is anything you wouldn't have understood in the video.

G. Not attempted.

H. Good to have the written record of the video.

I. Not attempted.

11. What are the advantages of the comic over the video and vice versa?

A. Video is alive - auditory and vision comic is necessary to recall; for reading skills and language comprehension video must be action wide on TV. Classroom activities recall in comic classroom situation.

B. The comic or the video is not enough. The advantage of the video is merely for entertainment but the advantage of the comic is to give facts to the pupils.

C. Should be used in conjunction with one another - The video stimulates, motivates, highlights peer group interest - The comic draws attention to dialogue language and concept of light.

D. Cheaper to produce. Don't need TV. and electricity to present to pupils.

E. Not attempted.

F. Helps in learning not only the scientific concepts but also the language (correct spelling)

G. Not attempted.

H. Comic can be looked at / read repeatedly in own time, video requires a video set and electricity.

I. Not attempted.

12. Do you think the comic can be used independent of the video or the video independent of the comic?

A. Video broadcast but will be double effective if comic is used afterwards because comic is reinforcement of video, especially because it is so colourful, neat clear script with excellent activities.

B. In case where the video is not available the comic can be enough for information but the video must always be used in collaboration with the comic.

C. See Q12.

D. Tells the same story

E. Not attempted.

F. I think it is best if they are used as a package more especially because the comic has certain activities which the pupils can do.

G. Not attempted.

H. In the class situation the video is sufficient. But if facilities are not available the pupils should read the comic at home before the activities are tackled to reinforce the concepts.

I. Not attempted.

13. What do you think are the disadvantages which the media could have on the learning process of primary school pupils?

A. Use focus (beforehand) on main themes.

B. Since it is said that this programme takes the whole year, I think it is too long to the extend that the children will treat light for the whole year while other topics of the syllabus are suffering. The children will like it is interesting.

C. Unless the video and comic are used in conjunction with activities there is the possibility that entertainment value will override meaningful learning.

D. Pupils could be solved with the spook part of the story they miss the point of light travelling in straight lines.

E. Not attempted.

F. If it is not reinforced by discussion and by the use of correct science terminology e.g. bouncing back is called reflection maybe there might be problems.

G. Not attempted.

H. There may be too much other destructing happenings and the children may loose track of scientific realities.

I. Not attempted.

14. What effect do you think this media could have on the development of the light concepts on the primary school teachers?

A. Pupils will learn to observe these concepts in their every day activities and their surroundings.

B. It will be successful in explaining some concepts.

C. Focuses on the need to teach facts in the context of the experience of the pupil.Highlights the importance of relating to peer group interests.

D. Useful - but a practical experiment outside (e.g. predict what will happen when I put light here & mirrors here. Place mirrors, observe what has happened, how did it happen, draw sketch of path of light) could achieve same/better results as pupils are personally involved.

E. Not attempted.

F. Stimulate observation and relating everyday things which actual concepts

G. Not attempted.

H. If the teachers do have any misconceptions about light this program should manage to clear this up.

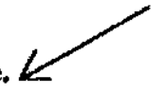
I. Not attempted.

APPENDIX F

SUMMARY OF PUPILS' RESPONSES TO DIAGNOSTIC QUESTIONS (Chapter 4)

NAME of INSTITUTION	R A Y		T Y P E		S		TOTAL No. of PUPILS
	1	2	3	4	5	6	
MA	7	1	0	0	30	1	39
NO	3	2	4	0	20	0	34
S T	18	9	0	0	22	0	49
TS	28	1	3	8	15	0	62
CM	16	4	5	1	21	6	55
MO	3	0	1	0	1	3	8

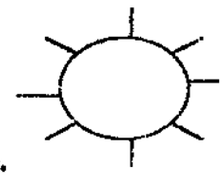
Key to ray types

1. Respondents drew light rays from the sun to the tree, i.e. 

2. Respondents drew light rays from the boy and the tree i.e. 

3. The same as in 2 above but with a connective ray from the boy's eyes to the tree i.e. 

4. Respondents drew light rays from the sun to the boy's eyes and then to the tree i.e. 

5. Respondents drew scattered rays from the sun i.e. 

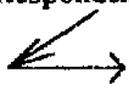
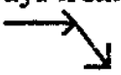
6. Respondents drew light rays from the sun to tree and then to the boy's eyes i.e. 

Table 4.1 Responses to Test No. 1 (Boy watching a tree)

NAME of INSTITUTION	R A Y		T Y P E		S		TOTAL No. of PUPILS
	1	2	3	4	5	6	
MA	4	0	12	0	0	1	39
NO	3	4	11	2	1	3	34
S T	2	0	19	0	2	1	49
TS	0	0	40	0	3	0	62
CM	3	0	28	0	2	2	55
MO	1	0	6	0	0	0	8

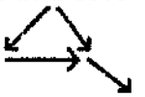
Key to ray types

1. Respondents drew light rays from the source to the first mirror straight to the trapped boy i.e. 

2. Respondents drew light rays from the first mirror to the second mirror and then to the trapped boy i.e. 

3. Respondents drew rays from the light source to the first mirror, then to the second mirror and finally to the trapped boy i.e. 

4. The same as in 3 above but light is reflected back from the trapped boy to the first mirror i.e. 

5. Light is scattered from the source to both the first and second mirror, and rays from the second mirror, to the trapped boy i.e. 

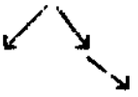
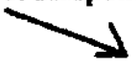
6. The same as in 5 above but there is no connection between the two mirrors i.e. 

Table 4.2 Responses to Test No.2 (Video animations)

NAME of INSTITUTION	R A Y		T Y	P E	S		TOTAL No. of PUPILS
	1	2	3	4	5	6	
MA	13	5	12	0	0	1	39
NO	7	8	11	2	1	3	34
S T	18	7	19	9	2	1	49
TS	22	8	40	0	3	0	62
CM	17	6	28	0	2	2	55
MO	2	0	6	0	0	0	8

Key to ray types

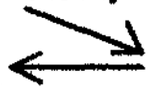
1. Respondents drew single rays from the light source to the reflectors i.e.



2. Respondents drew two rays, the top one from the light source to the reflector and the bottom one from the observer's eyes to the reflector i.e.



3. Respondents drew one ray from the light source to the observer's eyes then to the reflectors i.e.



4. Respondents drew light rays from the source to the observer's eyes and another ray from the observer's eyes to the reflectors i.e.



5. Respondents indicated the rays are scattered from the source to both the observer and reflecting objects i.e.



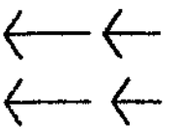
6. Respondents drew from the light source to both reflectors and the observer's eyes, and another from the observer's eyes to the reflectors i.e.



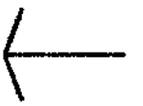
Table 4.3 Responses to Test No. 3 (Mirror and board)

NAME of INSTITUTION	R A Y		T Y	P E	S		TOTAL No. of PUPILS
	1	2	3	4	5	6	
MA	14	13	0	3	1	1	39
NO	9	14	5	2	2	0	34
S T	8	26	0	2	11	0	49
TS	2	34	2	1	5	0	62
CM	3	39	0	0	12	1	55
MO	3	5	0	0	0	0	8

Key to ray types

1. Respondents indicated parallel rays emited from the torch i.e 

2. Respondents indicated divergent rays from the torch i.e 

3. Respondents indicated single horizontal rays from the source i.e 

4. Respondents drew rays which bent downwards i.e 

5. Respondents drew rays which bent upwards i.e 

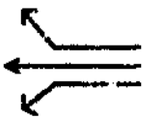
6. Respondents drew a combination of 4 and 5 above i.e 

Table 4.4 Responses to Test No. 4 (The boy holding a torch)

Author:Mahapa S S
Name of thesis:the effect of a primary school multi-media package and instruction on conceptual change in pre-service teachers

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