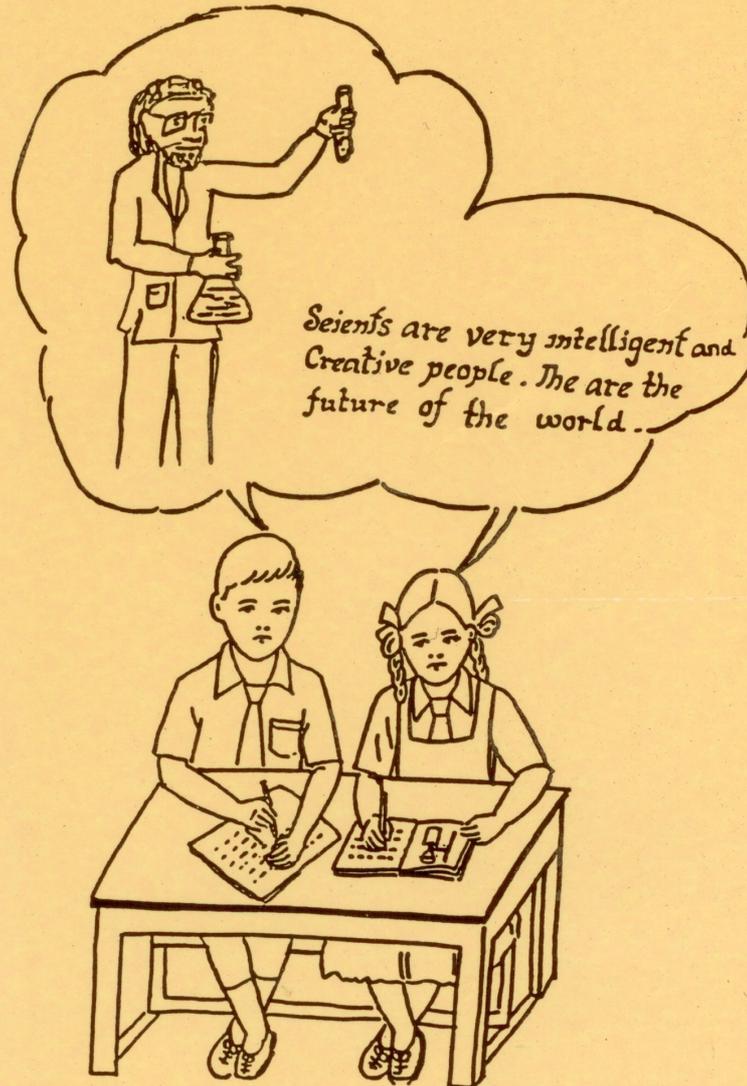


Students' Ideas About Science and Scientists

Sugra Chunawala and Savita Ladage



HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TATA INSTITUTE OF FUNDAMENTAL RESEARCH

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January 1998

Acknowledgements for cover illustrations:

1. Ms. Priya Kadam for the drawing of school children
2. Drawing of scientist and the write-up has been reproduced from students participating in the study (no corrections have been made)

ACKNOWLEDGEMENT

The work presented in the current technical report about Students' Ideas about Science and Scientists, is part of an International collaborative project sponsored by NORAD,. We express our gratitude to Prof. Svein Sjoberg (Norway), Dr. Jayashree Mehta (India) and Prof. Jane Mulemwa (Uganda) who were involved in the preparation of the questionnaire. We are especially obliged to Prof. Sjoberg for providing us the opportunity to participate in the project.

Two students of Tata Institute of Social Sciences, Ms. Anjali Nair and Ms. Rashmi Ingole, who did their fieldwork at HBCSE and Ms. Aparna Padmanabhan of HBCSE assisted in coding of parts of the data. Ms. Swapna Narvekar, has been a part of this project from its inception and has provided invaluable help at all stages of data collection, data entry and analysis. Shri. R.S Korgoankar provided help with the graphics while Shri. N.S. Thigale willingly helped with all the xeroxing and binding required for the study and the report.

We wish to thank all our colleagues at HBCSE for their suggestions and constructive criticism from time to time. Dr. Arvind Kumar, Director, HBCSE has throughout provided encouragement and support.

Finally, we would like to thank all the schools and the teachers for their cooperation in data collection and also the students who enthusiastically shared their ideas with us.

Sugra Chunawala and Savita Ladage

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Chapter 1

Introduction and Methodology

1.1 Introduction

"I think Scientists are highly intelligent and enthusiastic. They work hard to discover something, something one has never known before, totally extraordinary. They explore a new world. They work for the betterment of the people. They invent things which would make people's lives easy and comfortable. There were many great scientists like Homi Bhabha, C V. Raman, J.C Bose etc. I would definitely love to become a scientist not for fame or money but for satisfaction."

(Girl, VIII standard)

The above words written by a student reflect her positive attitude to scientists and the work they do. How do students view science and scientists? And is this perception important to science educators in any way? The development of better attitudes towards science is often recognized as an important aspect of science education and consequently the research into students' images of science has been around for quite some time.

1.2 Stereotypes of science and scientists

Stereotypes are simplified mental images which influence the incoming information. The term 'stereotype' was introduced by Walter Lippmann a journalist, in 1922. Lippmann was struck by the way the same event is perceived differently by different people. Perceptions about groups of people also have the same characteristic. To explain perceptions about groups, Lippmann borrowed the term 'stereotype' from the printing industry where it referred to a metal plate used in making duplicate pages of the same type. The term stereotype refers to generalizations about the characteristics of groups of people. Stereotyping is the process of ascribing characteristics to people on the basis of their group memberships. Stereotypes are rigid, persistent and resistant to change. At the same time, stereotyping is necessary as the human mind must think with the aid of categories (Oakes et. al, 1994).

With reference to science and scientists, Chambers (1983), states that in the eighteenth and nineteenth century, there were varied visual and verbal images of scientists which are rarely seen now. Though these images were stereotypic, their range was large. In these images scientists ranged from the diabolical madmen to harmless eccentrics, from learned buffoons to fashionable dilettantes. Black magic and alchemy were also invoked in connection with chemistry. However, as science has transformed its organizational structure, improved its general social status and has established its social authority, a new professional image has emerged in the media, which is a 'cleaned up' and standardized one. Thus the media presents science and scientists in a restricted way. This presentation creates images of science and scientists which are very limited.

As Sir Peter Medawar (1979) says in his *Advice to a Young Scientist* "There is no such person as the scientist..... Scientists are people of very dissimilar temperaments doing different things in very different ways. Among scientists are collectors, classifiers and compulsive tidiers-up; many are detectives by temperament and many are explorers; some are artists and others artisans. There are poet-scientists and philosopher-scientists and even a few mystics. What sort of mind or temperament can all these people be supposed to have in common? *Obligative* scientists must be very rare, and most people who are in fact scientists could easily have been something else instead."

Though most scientists would agree that the above description is apt, various studies have indicated that students possess highly stereotypic images of scientists (Barman, 1996). The classic work by Margaret Mead and Rhoda Metraux (1957) with high school students in the United States showed that students view science as natural science and the scientist as 'a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses'. The methodology used by Mead and Metraux was to ask students to write essays in response to questions.

Other tools to learn students' images of science have been questionnaires and interviews. Beardslee and O'Dowd (1961) explored college students' beliefs about scientists. After preliminary interviews students had been provided with a questionnaire in which students were asked to indicate the appropriateness of a series of terms. The terms were arranged on a two-ended seven point rating scale. This rating was done for 15 occupations including that of a scientist. A well defined stereotype of a scientist emerged in the ratings of students. The scientist emerged as a highly intelligent individual devoted to his studies and research at the expense of interest in art, friends and family. No gender differences existed in the views of students.

Joan Solomon and her colleagues (1994) obtained the following images of science through the use of questionnaires and interviews of students in the age range 11-14, in Britain. The images were:

the cartoon image of science /scientists,
scientists as vivisectionist,
the scientist as all knowing,
scientist as technologist,
teacher as scientist,
pupils as scientists and
scientists as entrepreneurs.

Solomon and her colleagues found that students did not hold just one kind of image of scientists, but several images. Students moved from one image to another in mid-conversation. Many images contained both the person and the equipment.

Children's drawings have long been used to explore students' images of science. According to Solomon, this is very easy methodology, with the pupils happy to reproduce the usual images which clearly show their comic intentions. She thus states that asking students to draw a scientist is equivalent to asking them to start fantasizing rather than reproduce reality. However, the 'Draw a Scientist Test' DAST devised by Chambers (1983) has the advantage that it does not depend on verbal facility and hence can be used with very young children too. This test was used by Chambers on around 5000 children in the age range of 5 to 11 during the periods 1966-77. This test has been used widely by researchers in different countries and the results have been compared (Ward 1986, Simpson and Girdham 1987, Fort and Varney 1989). Newton and Newton (1992) used the test and found that stereotypic images of scientists were acquired by children as early as six years of age.

A checklist for the DAST was prepared by Finson et al in 1995. The checklist focuses on the essential characteristics of the stereotypical image of scientists, which are: lab coat, eyeglasses, facial growth of hair, instruments and laboratory equipments, symbols of knowledge such as books etc., technology and relevant captions.

Huber and Burton (1995) made an attempt to study the changes in the drawings of students (grades 4-8, n=223) when their teachers attended an intervention programme, providing them with career information, role models, examination of sex-equitable materials and participation in innovative practices, specifically hands-on science investigation. The study had asked students to 'Draw a picture of a scientist at work', and had found that boys were more stereotypic in their drawings of scientists (male scientist, presence of eyeglasses, labcoat, funny hair, weird smile, wild eyes, beard, robotic features and scars). The posttest drawings after the intervention showed a greater movement towards less stereotypic drawings by boys.

Studies of the views of school teachers about science have also been conducted. Ramphal (1992) in a study of Indian school teachers reported that most teachers stated that they had never met a scientist, yet a large proportion of them felt that no formal qualifications were necessary to be a

scientist, if the appropriate qualities of 'discovery' were present. Patience/commitment was stated to be a prominent characteristic of scientists, more often than creativity or logical thought. Most teachers held that scientists are truly objective and are not influenced by factors such as pressures from external sources or need for personal gain, they also felt that the scientific temperament was reflected in everything about the scientists. More than half the teachers regarded scientists as unemotional. Scientists according to them do not even look like ordinary persons but appear 'serious and in thought' or 'brilliant but somewhat lost'. The last indicating the stereotype of the absent-minded professor.

One conclusion generated by these studies is that the image of science as a male-only domain remains the dominant perception in most students minds and despite efforts of science curriculum developers to depict scientists as people from all walks of life, students continue to perceive scientists as males. What are the possible reasons for this image?

Various sources are responsible for the images that students hold of science and scientists, and these are home, school, media, gender, culture and friends (Jane Johnston, 1996). According to Sjoberg and Imsen (1988) an image of science is a cumulative result of various school and out-of school influences. This study aims at learning Indian students perceptions of science and scientists by using various media such as drawing, writing and checklisting.

The study, 'Students Ideas About Science and Scientists' (SAS) is part of an international collaborative effort coordinated by Prof. Svein Sjoberg (Norway), Dr. Jayashree Mehta (India) and Jane Mulemwa (Uganda). It attempts to shed light on issues related to gender and science education, to identify differences in perceptions among girls and boys growing up in the same culture and to establish cross-cultural differences, if any. The questionnaire for data collection was prepared by the organizers, keeping in mind the international perspectives.

1.3 Methodology

The questionnaire was developed to be used by school children at the age of 13 years. This population is chosen for many reasons. In most countries, this age is towards the end of the primary stage, which often means that a large proportion of the age cohort is still at the school. In most countries it is also at an age before selection, curricular choices and streaming have taken place. These questions elicit the pupils' prior experience and some aspects of their views on science and scientists.

The questionnaire consisted of 7 tasks that students had to complete. In five of these tasks students had to indicate their responses by merely ticking an item. On one task students were expected to draw and write while on one task the student had to write to a larger extent. Each of

these tasks tapped a different perspective about science and scientists. The different tasks are described in greater detail in the following sub-sections:

1.3.1. Scientists as persons

This task tries to elicit what children think "real scientists" are like. Two opposite traits are put up on each side of a 5-point scale, the response is given by indicating a position on this scale. The "direction" of the different traits are mixed, so that what may be considered as a positive trait may occur at both ends of the scale. A distinction is made between a person working with physics or engineering (abbr.: a physicist) and a person working with biology or medicine (abbr.: a biologist), since previous research has indicated that the perceptions of these two `types' of scientists may be quite different.

1.3.2. Out of school experiences: What I have done

A large variety of culturally diverse activities are sampled and students are asked to describe if they have undertaken these activities or experienced them *outside the school* context. This task is an inventory of activities that may have bearing on the teaching and learning of science - and that may inform teachers and curriculum planners to provide a gender neutral curriculum. It may also indicate interesting differences in background experiences for children in different cultures.

1.3.3. Things to learn about

This task is similar to the above, but is an inventory of possible items for inclusion in the science curriculum. A positive response may indicate that students' would like to learn about it, or that they enjoyed learning about it. This list may be of value for curriculum planners and teachers. Also here, it is possible to find interesting differences between groups in the same country or differences between children in different cultures. An important follow-up in each country could be to compare "children's priorities" with what is actually taught.

1.3.4. Important for future job

This task presents a list of things that might be important for the choice of a future job. The pupil is invited to judge the personal relevance of a set of different aspects. Previous research has indicated interesting differences between girls and boys on such factors. There may also be interesting cultural differences.

1.3.5. Science in action

This task is a kind of word association test, where pupils are asked to place a tick for aspects they connect to "science". This item was expected to elicit some attitudes to science and some perceptions about what science may or may not contribute to. Such a "hidden curriculum" will be of interest for curriculum planners and teachers. We expect that there will be interesting variations between different groups on this item.

1.3.6. Scientists at work

The pupil is asked to make a *drawing* of a scientist at work (variation of the "Draw-a-Scientist" test). This is a qualitatively oriented task and the phrase "at work" is deliberately added, to draw attention to the thing scientists actually *do* - and not only how they may look. In the second part of this item, the pupil is invited to elaborate on the same aspect by writing something about it. This may be a story or just a list of key words.

1.3.7. Writing: Me as a scientist

In this last item, pupils are asked to put themselves in the position of a scientist doing research and express their own interest, concerns and priorities. Previous research has indicated interesting difference between the priorities of girls and boys. We may also identify cultural variations on this.

1.4 Administration of the questionnaire

The questionnaire was translated into Marathi with care and was administered in English medium and Marathi medium schools during the school hours. It generally took around 1.30 hours or two school periods to complete this activity.

1.5 Sample

The sample consisted of 444 students of class VIII (mean age 13 years) from eight schools of Mumbai (195 female students and 248 male students). Two of these schools had Marathi as the

medium of instruction (128 students) while the remaining schools had English as the medium of instruction (316 students). The schools selected were scholastically average.

1.6 Analysis

The analysis of the variables in the questionnaire had both a quantitative and qualitative component. The tasks 'scientists as person' 'out of school experiences' 'things to learn about' 'important for future job' and 'science in action' were analysed quantitatively. The analysis of drawings made by students of a 'scientist at work' and of short essay type questions relating to what a scientist does and 'me as a scientist' was qualitative in nature.

Chapter 2

Scientists as persons

2.1 Introduction

For the task 'Scientists as persons' which aimed at eliciting what students think "real scientists" are like, two opposite personality traits were put up on each side of a 5-point scale. The students had to respond by indicating a position on this scale. The "direction" of the different traits were mixed, so that what may be considered as a positive trait may occur at both ends of the scale. A distinction was made between a person working with physics or engineering (abbr.: a physicist) and a person working with biology or medicine (abbr.: a biologist), since previous research has indicated that the perceptions of these two "types" of scientists may be quite different. Table 2.1 below presents the percentage of students who ticked each of the five points on the scale as well as the mean (average) values with reference to a physicist. The means were calculated by considering the negative ends to begin with 1 and the positive end to be 5. In considering the response of students we concentrated on means above and below 2.5 and 3.5 and ignored the means around the average 3.

Table 2.1: Percentage responses to the question "I think the physicist is:" (n=444)

	1	2	3	4	5		Mean
Untidy, sloppy	3	9	17	46**	26*	Tidy, neat, orderly	3.82
Intelligent	52**	27*	8	7	8	Not intelligent,	4.08
Lacking imagination	5	10	16	32*	38**	Imaginative, full of ideas	3.89

Caring	16	24*	36**	15	9	Selfish	3.23
Lazy	3	3	13	40*	41**	Hardworking	4.13
Unsocial, loner	10	13	28*	31**	18	Social, outgoing	3.36
Boring person	7	10	19	38**	26*	Interesting person	3.66
Kind, humane	19	35**	32*	11	3	Unkind	3.55
Authoritarian	7	14	24*	27**	28	Democratic	3.56

** Largest percentage for the trait, * Second largest percentage

The total sample of students provided an overall positive impression of scientists (physicists and biologists). Physicists were positively placed for the following traits: tidy, intelligent, imaginative, interesting, kind and democratic. With respect to the pair of opposite traits: selfishness /caring, hardworking/lazy, and social/loner, physicists were placed by the students near the average yet on the positive side, that is hardworking, caring, and social.

Table 2.2 presents students' views about biologists. The traits selected by students which indicate the positive view of biologists were: tidy, intelligent, imaginative, caring and kind. With respect to traits such as, democracy, interesting, social and hardworking, biologists were rated near the average though on the positive side.

Table 2.2: Percentage responses to the question "I think the biologist is:" (n=444)

	1	2	3	4	5		Mean
Untidy, sloppy	6	7	11	29*	47**	Tidy, neat, orderly	4.05
Unintelligent	51**	25*	9	10	5	Intelligent	4.07
Lacking imagination	6	11	25*	33**	25	Imaginative, full of ideas	3.59
Caring	38**	21*	20	12	8	Selfish	3.69
Lazy	6	6	12	32*	45**	Hardworking	4.04
Unsocial, loner	7	11	23*	36**	23*	Social, outgoing	3.56
Boring person	11	10	22	30**	27*	Interesting and exciting person	3.52
Unkind	25*	34**	23	10	7	Kind, humane	3.60
Authoritarian	7	14	30**	26*	23	Democratic	3.45

** Largest percentage for the trait, * Second largest percentage

2.2 Comparison of physicists and biologists

A comparison of students' views about physicists and biologists was conducted by comparing the means (average) of students' responses using paired t-tests (Garrett 1966, Kerlinger 1983). There were four significant differences between physicists and biologists in the students' responses. Biologists in comparison to physicists were rated as neat and tidy (t value 3.10, 2 tailed probability 0.002), more caring (t value 6.27, 2 tailed probability 0.000) and more social (t value 2.50, 2 tailed probability .013). Physicists on the other hand were rated as more imaginative/full of ideas as compared to the biologists (t value 3.98, 2 tailed probability 0.000). The findings fit earlier ones that biology is viewed by students 'as a caring subject' while physics is viewed as a more 'brainy subject'. (Sjoberg and Imsen, 1988)

2.3 Gender differences

Differences in the responses of girls and boys to the same questions were measured by means of the t-test of differences in means (Garrett 1966). Table 2.3 presents the means of the responses of girls and boys to each trait of physicists and biologists, along with the t values and 2 tailed probabilities.

Table 2.3: Gender differences in students' percentage responses to questions about physicists and biologists (Girls = 195; Boys = 248)

No	Attributes	Physicist		Biologist	
		G (mean) B (mean)	t-values probabilities	G (mean) B (mean)	t-values probabilities
1	Untidy/tidy	G (3.78) B (3.84)	0.59 p = 0.56	G (4.09) B (4.00)	-0.75 p = 0.45
2	Unintelligent/Intelligent	G (4.09) B (4.07)	0.17 p = 0.86	G (4.09) B (4.05)	0.41 p = 0.68

3	Unimaginative /imaginative	G (3.95) B (3.83)	-1.14 p = 0.25	G (3.63) B (3.57)	-0.51 p = 0.61
4	Selfish/caring	G (3.31) B (3.18)	1.20 p = 0.23	G (3.73) B (3.65)	0.66 p = 0.51
5	Lazy/hardwork king	G (4.08) B (4.16)	0.73 p = 0.47	G (4.02) B (4.05)	0.25 p = 0.80
6	Unsocial/social	G (3.38) B (3.34)	-0.41 p = 0.69	G (3.65) B (3.49)	-1.47 p = 0.14
7	Boring/interest ing	G (3.64) B (3.66)	0.24 p = 0.81	G (3.59) B (3.40)	-1.76 p = 0.08
8	Unkind/kind	G (3.55) B (3.56)	-0.05 p = 0.96	G (3.64) B (3.59)	0.36 p = 0.72
9	Dominating/de mocratic	G (3.67) B (3.50)	-1.43 p = 0.15	G (3.51) B (3.41)	-0.85 p = 0.40

It is interesting that both girls and boys held similar views about scientists and that there were no statistically significant gender differences in students' ideas about the traits of physicists and biologists.

2.4 Differences by medium

Differences in the responses of English medium students and Marathi medium students were measured by means of the t test of differences in means (Garrett, SPSS).

Table 2.4: Medium-wise differences in students' percentage responses to questions about physicists and biologists (Marathi = 128; English = 316)

No	Attributes	Physicist		Biologist	
		E (mean) M (mean)	t-values probabilities	E (mean) M (mean)	t-values probabilities
1	Untidy/tidy	E (3.76) M (3.97)	-1.97 p = 0.05*	E (3.95) M (4.28)	-2.86 p = 0.01*
2	Unintelligent/intelligent	E (4.18) M (3.82)	-2.75 p = 0.01*	E (4.08) M (4.03)	-0.40 p = 0.69
3	Unimaginative/imaginative	E (3.92) M (3.82)	0.79 p = 0.43	E (3.55) M (3.70)	-1.19 p = 0.23
4	Selfish/caring	E (3.15) M (3.44)	2.37 p = 0.02*	E (3.74) M (3.55)	-1.30 p = 0.20
5	Lazy/hardworking	E (4.13) M (n.a)	can't compute	E (4.03) M (n.a)	can't compute
6	Unsocial/social	E (3.39) M (3.26)	1.03 p = 0.30	E (3.51) M (3.70)	-1.53 p = 0.13
7	Boring/interesting	E (3.66) M (3.67)	-0.08 p = 0.93	E (3.48) M (3.63)	-1.14 p = 0.25
8	Unkind/kind	E (3.69)	-4.64 p = 0.00*	E (3.74)	-3.74 p = 0.00*

		M (3.20)		M (3.26)	
9	Dominating/democratic	E (3.50)	-2.18 p = 0.03*	E (3.37)	-2.17 p = 0.03*
		M (3.77)		M (3.64)	

* - significant difference

Table 2.4 presents the means of the responses of girls and boys to each trait of physicists and biologists, along with the t values and 2 tailed probabilities. In the table one can see that the lazy/hardworking is designated as not applicable for Marathi medium students. This was due to an oversight in the questionnaire translation where this category was not translated. The above table indicates that the students of Marathi medium were more positive towards both physicists and biologists than the English medium students. They viewed the physicist as more tidy, intelligent, caring and democratic, and the biologist as more tidy and democratic than the English medium students. The latter had viewed the physicist and the biologist as more kind than the Marathi medium students had.

Chapter 3

Students' experiences, interests, views about science and future job

3.1 Students' out of school experiences

Sjoberg and Imsen (1988) have pointed out that children bring with them to school different types of experiences and by taking some experiences for granted and as a starting point for teaching we may be unintentionally favouring some groups of students. The study presented a list of various activities and asked students to say if they had done these activities outside school, never, seldom or often. The responses were graded as 1 for never, 2 for seldom and 3 for often. The mean value for each activity thus could range from 1 to 3. In practice we found that the range was between 1.05 and 2.97. Mean values for students' out of school experiences were calculated and are presented below.

Table 3.1: Mean values of 'out of school' experiences for girls, boys, Marathi and English medium students

Have you done this outside school?	E	M	t-values	B	G	t-values
01. Sewed	2.51	2.61	-1.55	2.45	2.65	-
02. Knitted	1.18	1.40	-3.59*	1.11	1.43	3.40*
03. Weaved	1.14	1.17	-0.69	1.10	1.22	-
04. Made clothes	1.20	2.01	-10.60*	1.38	1.49	6.60*
05. Used a saw	1.80	1.58	2.93*	1.95	1.46	-
06. Used a screw-driver	2.58	2.38	2.97*	2.71	2.28	3.11*
07. Used a hammer and nail	2.38	2.30	1.17	2.54	2.12	-1.65
08. Used pulleys	1.82	1.38	3.64*	1.73	1.66	7.42*
09. Used a hand-pump	1.94	1.54	5.15*	1.94	1.70	7.09*
10. Climbed a tree	2.19	2.35	-2.06*	2.45	1.96	6.50*
11. Made toys	1.83	1.52	4.23*	1.85	1.61	0.40
12. Made a kite	2.24	2.20	0.42	2.34	2.08	3.36*
13. Building kits	2.23	1.98	2.90*	2.18	2.14	7.02*
14. Used a radio	2.80	2.89	-2.02*	2.82	2.83	3.39*
15. Used a tape-recorder	2.49	2.19	3.92*	2.44	2.37	3.61*
16. Used a video-recorder	1.99	1.50	6.12*	1.90	1.80	0.48
17. Played video/computer games	2.44	2.01	4.95*	2.42	2.18	-0.07
18. Used a calculator	2.66	2.61	0.77	2.65	2.64	0.94
19. Used a personal computer	1.57	1.61	-0.44	1.71	1.42	1.17
20. Played with lights/mirrors	2.32	2.18	1.89	2.36	2.17	3.32*

21. Used a magnifying glass	2.07	2.28	-2.53*	2.19	2.06	0.20
22. Used a microscope	1.79	1.68	1.39	1.79	1.71	4.03*
23. Used binoculars	2.21	1.78	5.13*	2.15	2.00	2.87*
24. Used a camera	2.50	2.32	2.28*	2.46	2.42	1.64
25. Developed a processed films	1.11	1.08	0.92	1.14	1.05	1.09
26. Used a wrist watch	2.77	2.85	-1.60	2.79	2.78	1.90
27. Used a stop watch	1.85	1.42	5.92*	1.85	1.57	0.65
28. Used a measuring tape	2.57	2.80	-4.43*	2.65	2.62	2.77*
29. Read a thermometer	2.29	2.02	3.42*	2.27	2.15	0.19
30. Used a kitchen scale	1.74	2.19	-5.64*	1.88	1.86	3.84*
31. Read a map/compass	2.36	2.01	4.45*	2.31	2.19	0.44
32. Used an airgun or rifle	1.42	1.29	1.99	1.53	1.20	1.69
33. Made bow and arrows/sling	1.88	1.84	0.47	2.07	1.61	0.23
34. Preserved food (salting etc)	1.58	1.46	1.68	1.52	1.59	1.69
35. Made bread	1.37	1.34	0.29	1.21	1.55	5.80*
36. Collected edible berries	1.77	2.16	-5.35*	1.84	1.94	6.35*
37. Made jam.	1.26	1.70	-6.24*	1.35	1.43	-1.11
38. Planted seeds	2.35	2.03	4.52*	2.32	2.19	-
39. Studied the life in a pond	1.57	1.53	0.55	1.64	1.46	2.02*
40. Read about body functions	2.41	2.29	1.49	2.44	2.29	-1.43
41. Made a compost	1.44	1.56	-1.83	1.54	1.38	-1.24
42. Made a sieve	1.31	1.23	1.49	1.35	1.20	2.00*
43. Made a funnel	1.81	1.66	1.21	1.87	1.64	2.83*
44. Put bandages on wounds	2.63	2.57	1.02	2.64	2.58	2.30*
45. Watched a bird make nests	2.06	1.94	1.74	2.09	1.95	2.62*
46. Watched an egg hatching	1.63	1.56	0.92	1.66	1.54	3.15*
47. Watched animals feed their young	2.40	2.25	2.06*	2.42	2.28	1.60
48. Cared for an animal	1.83	1.92	-1.10	1.92	1.77	1.01
49. Milked a cow/ goat	1.47	1.48	-0.16	1.52	1.42	2.20*
50. Made yogurt, butter etc	1.59	2.05	-5.86*	1.62	1.86	1.77
51. Made chalk or candles	1.31	1.19	2.15*	1.33	1.21	2.09*
52. Had a pet animal	1.74	1.66	1.00	1.73	1.70	1.95*
53. Chopped wood/ collected firewood	1.57 1.42	2.12 1.63	-6.85* -2.51*	1.88 1.65	1.55 1.26	1.29 -
54. Made charcoal	1.89	2.21	-3.91*	2.10	1.83	3.38*
55. Made a fire	1.18	1.12	1.37	1.22	1.09	2.31*
56. Made colour dyes	1.59	1.45	2.00*	1.60	1.50	0.39
57. Put up a tent/shelter	2.03	2.19	-2.02*	2.19	1.92	4.69*
58. Walked with a load on head	2.74	2.59	2.29*	2.79	2.57	6.09*
59. Played with magnets	2.36	2.15	2.59*	2.53	2.02	3.66*
60. Played with batteries	2.60	2.08	6.69*	2.52	2.38	3.32*
61. Used electric toys	1.78	1.51	3.46*	1.88	1.49	1.59
62. Changed a fuse	1.58	1.53	0.70	1.65	1.47	3.74*
63. Studied the inside of T.V, radio	2.77	2.61	2.26*	2.81	2.61	4.25*
64. Rode a bicycle	1.62	1.94	-4.00*	1.88	1.51	7.32*
65. Mended a bicycle tube	1.21	1.09	3.36*	1.26	1.07	2.01*
66. Used a car jack	1.59	1.38	2.66*	1.55	1.51	5.57*
67. Charged a car or other battery	1.15	1.17	-0.51	1.18	1.12	2.77*

68. Made a cart/ wheelbarrow	2.00	2.03	-0.41	2.04	1.97	3.42*
69. Observed the Milky Way	2.11	1.93	2.54*	2.12	1.99	5.15*
70. Observed the phases of the moon	2.15	2.27	-1.76	2.18	2.19	4.68*
71. Observed rainbow or clouds	1.46	1.62	-2.24*	1.57	1.44	0.61
72. Studied fossils	2.36	2.47	-1.63	2.38	2.41	1.31
73. Made anything from clay	1.23	1.26	-0.52	1.31	1.14	0.96
74. Made bricks	1.35	1.16	3.63*	1.32	1.26	1.91
75. Made a flute	2.26	2.14	1.61	2.21	2.26	-0.90
76. Collected stones or gems	2.53	2.60	-1.16	2.55	2.54	2.19*
77. Thrown stones to watch water ripples	1.50	1.18	5.84*	1.51	1.28	-0.33
78. Made a wind or water mill	2.68	2.74	-1.16	2.70	2.69	3.34*
79. Blown soap bubbles	1.08	1.06	0.80	1.10	1.05	1.14
80. Participated in brewing beer						-0.73
						0.14
						3.77*
						0.26
						2.02*

- = significant differences, E= English, M= Marathi, B =Boys, G =Girls

3.1.1 Gender differences in students' experiences

It is important to note that of the 80 'out of school' experiences that were presented to students, more of the activities were reportedly done by boys than girls. The mean reported by boys for many activities was higher than that of the mean reported by girls. Between girls and boys the difference in the means was significant for 45 of the eighty activities (t-tests). The activities for which there was a significant difference in the means are presented below:

Table 3.2: Gender differences in students' 'out of school' experiences

Activities on which more boys had participated	Activities on which more girls had participated
01. Used a saw	1. Sewed
02. Used a screw-driver	2. Knitted
03. Used a hammer and nail	3. Weaved
04. Used a hand pump	4. Made bread
05. Climbed a tree	5. Made yoghurt / butter
06. Made toys	
07. Made a kite	
08. Played video / computer games	
09. Used a personal computer	
10. Played with lights and mirrors	

11. Developed and processed film 12. Used a stop-watch 13. Used an air-gun or rifle 14. Made bow and arrow/ catapult 15. Planted seeds 16. Studied the life in a pond 17. Read about body functions 18. Made a compost 19. Made a sieve 20. Watched a bird make nests 21. Watched animals feed their young 22. Cared for an animal 23. Made chalk / candles 24. Chopped wood/ collected firewood 25. Made charcoal 26. Made a fire 27. Made colour dyes 28. Walked with a load on head 29. Played with magnets 30. Played with batteries 31. Used electric toys 32. Changed a fuse 33. Studied the inside of a TV/ radio 34. Rode a bicycle 35. Mended a bicycle tube 36. Used a car jack 37. Observed rainbows or clouds 38. Made anything from clay 39. Made a wind mill or water mill 40. Participated in brewing beer	
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The table indicates that the number of activities on which more boys had participated outside school (40) were many more than the number of activities on which more girls had participated (5). But it is not the number of activities alone that is important but also the kind of activities which show a gender difference. All the five activities reported more often by girls were connected to the *home*. To be more specific these activities are related to the kitchen (making, bread, butter or yoghurt) or are related to sewing, weaving and knitting. In fact, cooking and stitching were and are skills emphasised for every girl in most social settings.

The activities dominated by boys have a large range. They are related to *use of tools and equipment* (saw, screw driver, hammer and nail, video, personal computer, stop-watch, airgun, electric toys, magnets, batteries and bicycle, developing film, mending a bicycle tube, using a car jack, changed a fuse, studying the inside of a TV or radio, playing with light and mirrors)

making something (toys, kite, bow and arrow, compost, fire, sieve, chalk, charcoal, colour dyes, clay articles, windmill or water-mill, brewing beer) *nature and environment* (caring for an animal, watching animals feeding their young, watching birds make nests, planting seeds, studying the life inside a pond, studying body functions, climbing trees, chopping wood collecting firewood, walking with a load on head, observing clouds and rainbows).

Most of the activities in the list presented to the students have some relevance to science and can possibly serve as concrete examples of what is to be taught or as starting points for school science. Thus it would appear that science builds on the experience that boys have acquired to a greater extent than girls do.

3.1.2 Differences in students' experiences by medium of education

Of the eighty activities presented to the students, the English medium students had participated in many more activities outside school as compared to the Marathi medium students. There were statistically significant differences on 44 of the eighty activities. These activities are presenting below:

Table 3.3: Medium-wise differences in students' `out of school' experiences

Activities on which more English medium students had participated	Activities on which more Marathi medium students had participated
01. Using a saw	01. Knitting
02. Using a screw-driver	02. Made clothes
03. Using pulleys	03. Climbing a tree
04. Using a hand-pump	04. Using a radio
05. Made toys	05. Using a magnifying glass
06. Using building kits	06. Using a measuring tape
07. Using a tape-recorder	07. Using a kitchen scale
08. Using a video-recorder	08. Collecting edible berries
09. Playing video/computer games	09. Made jam
10. Using binoculars	10. Made yoghurt/butter
11. Using a camera	11. Had a pet animal
12. Using a stop watch	12. Chopping wood/ collecting firewood
13. Read a thermometer	13. Made charcoal
14. Read a map /compass	14. Walking with a load on the head
15. Planting seeds	15. Mending a bicycle tube
16. Watching animals feed their	

young 17. Made chalk / candles 18. Put up a tent or shelter 19. Playing with magnets 20. Playing with batteries 21. Using electric toys 22. Changing a fuse 23. Rode a bicycle 24. Using a car jack 25. Charging a battery 26. Observing the phases of the moon 27. Made a flute 28. Made a wind or water mill	16. Studying fossils
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As can be seen above, the activities more often reported by Marathi medium students were fewer in number as compared to the English medium students. This was similar to the fact that girls had reported fewer activities, another similarity was that like the activities reported by girls, the activities reported by the Marathi medium students were more related to *home* skills such as (knitting, making clothes, using a measuring tape, using a kitchen scale, making jam, yoghurt and butter). However, the range of activities was wider than that reported by girls. Marathi medium students reported a few activities related to *nature* (having a pet animal, collecting berries, chopping wood and climbing trees, studying fossils and walking with a load on head) and a few activities involving *tools and equipments* (using a radio, a magnifying glass and mending bicycle tube) and making something (charcoal).

The English medium students had participated in many activities involving *tools and equipments* (saw, screw driver, handpump, pulleys, building kits, video-recorder, tape recorder, computer, stop-watch, camera, binoculars, thermometer, map/ compass, electric toys, magnets, batteries and bicycle, using a car jack and changed a fuse) *making something* (toys, chalk, windmill or water-mill, flute, put up a tent) and less related to *nature and environment* (watching animals feeding their young, planting seeds, observed the phases of the moon).

3.2 Students' interests; or what they would like to learn

Students were presented with a large list of (69) topics and asked if they would like to learn more about these topics. The aim of the exercise was to learn what are the topics that students are more interested in and would like specifically to have in their school syllabii. Since

they merely had to tick the items only percentages were possible and the z test of probabilities.

Table 3.4: Percentages and differences by gender and medium of instruction (z test)

Things to learn	G %	B %	D	z	E %	M %	D	z
1. The car & how it works	64	80	-	-	76	66	10	2.07*
2. Pollution & dangers of traffic	56	60	16	3.74	60	53	06	1.35
3. Why birds and planes can fly	80	85	-	*	80	90	-10	-
4. How birds/animals communicate	83	69	04	-	74	78	-04	2.87*
5. How birds & fish find way home	73	69	-	0.84	73	66	07	-0.90
6. Plants/animals in the neighbourhood	63	61	05	-	55	77	-20	1.43
7. Plants/animals elsewhere	76	75	14	1.95	75	77	-02	-
8. How the body is built & functions	80	75	04	3.51	74	85	-11	4.72*
9. Bacteria, viruses & diseases	69	73	02	*	69	77	-08	-0.45
10. Vaccination & prevention	64	71	01	0.92	69	77	-08	-
11. AIDS	64	71	05	0.43	71	60	11	2.74*
12. How plants grow & their needs	74	70	05	0.24	73	70	03	-1.76
13. How to eat/cook food the best way	71	68	-	1.25	67	75	-08	2.18*
14. What we should eat to be healthy	65	57	04	-	57	67	-10	0.63
15. How babies are made and grow	80	77	07	0.92	74	88	-14	-1.72
16. Detergents, soaps & how they work	69	63	04	-	63	70	-07	-
17. Evolution of life on earth	43	48	03	1.56	48	38	10	1.99*
18. Dinosaurs	70	82	08	0.93	76	80	-04	-
19. Origin & evolution of humans	88	89	03	0.68	86	95	-09	3.69*
20. Plants & animals inter-dependence	74	69	06	1.72	67	82	-15	-1.43
21. Light & optics	57	57	-	0.76	57	56	01	1.95
22. How the eye can see	54	68	05	1.32	59	71	-12	-0.93
23. Colours & how we see them	82	82	-	-	80	86	-06	-
24. Acoustics and sound	73	70	12	1.05	69	77	-08	3.28*
25. How animals & plants use colours	47	61	-	-	57	48	09	-
26. How the ear can hear	74	76	01	2.93	74	78	-04	3.42*
27. Music, instruments & sounds	71	77	05	*	71	82	-11	0.19
28. Sound & music of birds & animals	68	71	00	-	72	66	-05	-
29. Earthquakes & volcanoes	73	69	-	0.32	72	66	-05	2.46*
30. Lightning & thunder	73	85	14	1.16	71	71	00	-1.57
31. Clouds, rain and snow	71	72	00	000	81	77	04	-1.76
32. What is the rainbow/ why you see it	71	72	00	-	71	73	-02	1.72
33. Weather & forecast	72	68	03	3.01	67	76	-09	-0.90
34. Mountains, rivers & oceans & develop	82	75	-	*	73	91	-18	-
35. Why the sky is blue/stars twinkle	49	57	14	000	53	54	-01	2.58*
36. The greenhouse effect	63	67	02	1.21	62	74	-12	-1.22
37. The ozone layer	82	79	06	-	81	77	04	000
38. The moon, the stars & planets	55	55	-	2.96	59	46	13	0.92
39. Universe/stars constellations	64	68	03	*	65	69	-04	-0.42
40. Rockets & space travel	85	82	04	0.48	81	88	-07	-1.95
41. Possibility of life outside earth	77	79	-	-	77	83	-05	-
42. Electricity, produced & used at home	80	85	12	1.42	82	85	-03	5.06*
43. New sources of energy (sun wind)	83	81	-	-	81	84	-03	-0.19
44. How telephone, radio, TV work	52	63	01	0.68	58	59	-01	-
45. Computers & what are they for	55	68	04	0.92	65	56	09	2.53*
46. Latest developments in technology	68	72	07	-	72	66	06	0.92
47. Satellites and modern communications	79	79	-	3.07	76	86	-10	2.49*
	62	68	08	-	67	60	07	-0.81
	59	67	-	0.23	64	61	03	-1.93
	72	70	04	0.91	70	73	-03	-1.47
			03	1.80				

48. S & T towards better life	60	65	00	-	64	59	05	-0.78
49. Possible dangers of S & T	59	57	-	1.67	53	70	-17	-0.76
50. Plants we can eat & harvest	54	54	04	-	53	57	-04	-0.19
51. Food processing/conservation/storage	61	64	03	0.87	68	49	19	1.75
52. Poisonous plants & mushrooms	56	55	-	0.79	53	62	-09	1.22
53. Improving harvest in gardens & farms	76	78	02	000	74	84	-10	-
	69	74	-	-	73	67	06	2.56*
54. How to get clean/safe drinking water	63	68	05	0.88	66	65	01	1.38
55. How to protect environment	59	61	02	0.84	65	48	17	0.59
56. X-rays & ultra sound machines	49	54	-	-	54	46	08	-0.63
57. Test-tube babies	75	72	11	0.50	70	83	-13	0.97
58. Birth control & contraceptives	79	72	-	-	71	85	-14	-
59. Children in other parts of the world	73	72	13	1.36	71	85	-14	-3.44*
60. How people look in different regions	80	76	-	0.54	69	82	-13	-0.76
61. S & T to help the disabled	80	76	04	-	78	77	01	3.69*
62. How scientists think & work	60	68	00	2.33	61	71	-10	-1.75
63. Famous scientists & their lives	76	82	-	*	78	85	-07	-
64. Important inventions & discoveries	61	67	06	-	72	45	27	-2.45*
65. How a nuclear power plant functions	74	83	-	2.80	74	91	-17	1.23
66. What an atomic bomb consists of	59	67	08	*	60	71	-11	0.20
67. Radioactivity effects on life	71	77	02	-	69	86	-17	3.29*
68. Atoms & molecules	79	82	-	0.91	78	88	-10	1.53
69. Chemicals & their properties			05	000				-
			02	-				-
			00	1.31				3.09*
			-	-				-
			03	1.73				3.44*
			01	0.46				-
			-	-				3.03*
			02	1.07				0.22
			-	0.42				-
			05	000				2.05*
			-	-				-1.78
			05	0.64				5.32*
			-	0.21				-
			02	-				4.81*
			-	0.41				-
			05	-				2.26*
			03	1.15				-
			07	-				4.22*
			01	1.09				-
			04	-				2.70*
			-	0.42				-
			08	-				-
			-	1.04				-
			06	0.71				-
			-	1.71				-
			06	0.23				-
			-	1.01				-
			09	-				-
			-	1.74				-
			08	-				-
			-	1.53				-
			06	-				-
			-	1.30				-
			03	-				-
			-	2.28				-
			-	*				-
			-	1.73				-

Table 3.6: Medium-wise differences in learning choices

Topics preferred by English medium students	Topic preferred by Marathi medium students
<ol style="list-style-type: none"> 1. How a nuclear power plant functions. 2. Test-tube babies. 3. Poisonous plants and mushrooms. 4. Vaccination and prevention. 5. The car and how it works. 	<ol style="list-style-type: none"> 1. Chemicals and their properties. 2. Atoms and molecules. 3. How radioactivity affects life and human body. 4. What an atomic bomb consists of. 5. Famous scientists and their lives. 6. S & T to help the disabled. 7. Why people in different regions look different. 8. Children in other parts of the world. 9. How to get clean drinking water. 10. Plants we can eat and harvest. 11. Computers and what we can do with them. 12. Mountains, rivers, oceans and how they develop. 13. The rainbow, what it is and why you see it. 14. How the ear can hear. 15. Light and optics. 16. Origin and evolution of humans. 17. Dinosaurs. 18. What we should eat to be healthy. 19. How to eat and cook food the best way. 20. Plants and animals in the neighbourhood. 21. How the body is built and functions. 22. Why birds and planes can fly.

It would be interesting to learn why the Marathi medium students differ from the English medium students on so many topics. This is one area which could be explored more in detail.

3.3 What students consider important for future job

A list of attributes were presented to students who were asked to rate the attributes as 'not important-1', 'of some importance-2' and 'very important-3'. Students had to rate these attributes with reference to importance for a future job. This question would provide

information as to what are the qualities that students give a priority to and would like to see satisfied in their jobs.

Table 3.7: Mean ratings and rankings of attributes 'important for future job'

Important for future job	Mean	Rank
1. Work with people	2.25	11
2. Have time for friends	1.97	14
3. Use my talents/abilities	2.78	01
4. Earn lots of money	2.22	12
5. Have an exciting job	2.75	02
6. Have time for family	2.50	07
7. Make own decisions	2.65	05
8. Make and invent things	2.56	06
9. Control people	1.98	13
10. Become famous	2.35	09
11. Get a secure job	2.42	08
12. Have time for interests/hobbies	2.31	10
13. Help other people	2.68	03
14. Have an easy and simple job	1.92	15
15. Develop new knowledge/skills	2.67	04

Students when assessing the importance of various attributes for a future job ranked the following attributes highly; 'use of my talents' 'have an exciting job', 'help other people', 'develop new knowledge/skills' and 'ability to take one's own decisions'. The attributes for a job ranked as unimportant by more students were; 'have an easy and simple job', 'have time for friends', 'control people', 'earn lots of money' and 'work with people instead of things'. The attributes which fell between in between these two were; 'have time for one's hobbies', 'become famous', 'get a secure job', 'have time for for family' and 'make and invent things'.

3.3.1 Gender differences in attributes considered important for a job

Table 3.8: Mean ratings, rankings and differences in attributes 'important for future job' by gender (t-values)

Important for future job	Boys Mean	Boys Rank	Girls Mean	Girls Rank	t values
1. Work with people	2.24	12	2.27	11	-0.36
2. Have time for friends	1.91	14	2.03	13	-1.76
3. Use my talents/abilities	2.74	02	2.83	01	-1.60

4. Earn lots of money	2.26	11	2.16	12	1.50
5. Have an exciting job	2.76	01	2.74	02	0.40
6. Have time for family	2.50	07	2.50	06.5	0.02
7. Make own decisions	2.60	06	2.70	03.5	-1.58
8. Make and invent things	2.62	04	2.48	08	2.24*
9. Control people	2.02	13	1.92	15	1.40
10. Become famous	2.35	09	2.35	09.5	-0.04
11. Get a secure job	2.36	08	2.50	06.5	-2.05*
12. Have time for hobbies	2.28	10	2.35	09.5	-0.98
13. Help other people	2.67	07	2.68	05	-0.16
14. Have easy and simple job	1.88	15	1.97	14	-1.38
15. Develop new knowledge	2.66	04	2.70	03.5	-0.67

* = significant differences

There were very few significant gender differences in the attributes considered important for a future job by students. However, more boys stated that they wanted a job that would allow them to make and invent things, while more girls stated that they wanted a secure job.

3.3.2 Difference in attributes considered important for a job by medium of instruction

Table 3.9: Mean ratings, rankings and differences in attributes 'important for future job' by medium (t-values)

Of importance for future job	English Mean	English Rank	Marathi Mean	Marathi Rank	t-values
1. Work with people	2.24	12	2.28	10	-0.50
2. Have time for friends	1.99	13	1.91	14.5	1.17
3. Use my talents/abilities	2.73	01	2.89	01	-3.20*
4. Earn lots of money	2.26	11	2.11	12	2.09*
5. Have an exciting job	2.71	02	2.84	03	-2.67*
6. Have time for family	2.51	06	2.48	07.5	0.36
7. Make own decisions	2.57	05	2.82	04	-4.63*
8. Make and invent things	2.49	07	2.73	06	-4.03*
9. Control people	1.96	14	2.02	13	-0.74
10. Become famous	2.30	10	2.48	07.5	-2.26*
11. Get a secure job	2.45	08	2.37	09	1.09
12. Have time for hobbies	2.33	09	2.27	11	0.80
13. Help other people	2.64	03	2.77	05	-2.27*
14. Have easy and simple job	1.93	15	1.91	14.5	0.17
15. Develop new knowledge	2.60	04	2.86	02	-4.79*

* = significant differences

In connection with medium of instruction there were quite a few statistically significant differences as to what the students considered important in a job. Eight of the fifteen characteristics about job were rated differently by students in the two media. More Marathi medium students emphasised, using their abilities, having an exciting job, making own decisions, making inventions, becoming famous, helping other people and developing new knowledge. The only characteristic that was emphasised by English medium students was earning lots of money.

3.4 Science in Action

Thirteen attributes of science were presented to students, who were asked to tick those which spontaneously came to their minds whenever science was mentioned. The following table presents the percentage of time an attribute was ticked by the total sample and a ranking of the attributes, based on these percentages.

Table 3.10: Students' views about 'science in action' (444 students)

Science is/ causes:	Total %	Rank
1 Interesting	96	1
2 Boring	06	13
3 Problems	27	12
4 Pollution	43	8
5 Useful	94	2
6 Experiments	87	3
7 For boys	30	10
8 Power	74	6
9 Important	83	4
10 Destructive	35	9
11 Helps poor	65	7
12 Difficult	29	11
13 Easy	76	5

The above table displays percentages of students giving a particular response and the ranks based on the percentages. Five most often mentioned attributes of science as seen from the above table are: that science is; *interesting, useful, experimental, important for society* and *easy*. As against this, the five least often mentioned attributes are that science is: *boring,*

problematic, difficult, for boys and destructive. The remaining three attributes which were between the two are that science: *causes pollution, helps poor* and *is power.* These responses clearly reveal that students have a highly positive image of science, as the negative attributes are ranked lower than the positive ones.

3.4.1 Gender differences in students' views about `science in action'

The following table presents the percentages of girls and boys stating the attributes of science (from those given) and the ranking of the attributes based on these percentages. The difference in the percentage of attributes ticked by boys in comparison to girls, and z tests based on the same are presented in the table.

Table 3.11: Gender differences in students' views of `science in action'

Science is:	Girls %	Rank	Boys %	Rank	Difference %	z test
1 Interesting	98	1	94	1	04	2.21 *
2 Boring	02	13	09	13	-07	-3.37 *
3 Problems	28	9	27	12	01	0.23
4 Pollution	34	8	50	8	-16	-3.44 *
5 Useful	96	2	93	2	03	1.40
6 Experiments	86	4	88	3	-02	-0.61
7 For boys	15	12	42	9	-27	-6.67 *
8 Power	69	6	78	5	-09	-2.12 *
9 Important	87	3	81	4	06	1.73
10 Destructive	28	9	41	10	-13	-2.90 *
11 Helps poor	64	7	66	7	-02	-0.44
12 Difficult	28	9	30	11	02	-0.46
13 Easy	76	5	75	6	01	1.19

*** = significant differences**

Both boys and girls displayed a positive image of science in general. The ranking by girls showed the same five attributes stated above by the total sample as the more often mentioned attributes of science, that is, science is: *interesting, useful, experimental, important for society* and *easy* as against the five least important ones that science is: *boring, problematic, difficult,*

for boys and destructive. Boys, however, included power in the 5 most important attributes instead of science is easy.

There are six significant differences in the scoring by girls and boys. More girls viewed science as interesting, while more boys viewed science as boring, as the cause of pollution, as a source of power, as destructive and as being for boys. Girls thus appeared to be more positive towards science. No negative attribute was ticked by girls significantly more often than boys. That science is 'for boys' was ticked by both girls and boys, however boys ticked this attribute, more often than did girls.

3.4.2 Medium-wise differences in students' views about science

Comparison of the responses of students studying in English and Marathi media to the attributes of science are presented in Table 3.12

Table 3.12: Medium-wise differences in students' responses to 'Science in action'

Science is/ causes:	English %	Rank	Marathi %	Rank	Difference	z test
1 Interesting	95	2	98	1	-03	-1.72
2 Boring	08	13	02	13	06	3.05 *
3 Problems	27	12	28	9	-01	-0.21
4 Pollution	47	8	33	8	14	2.79 *
5 Useful	96	1	91	3	05	1.81
6 Experiments	85	3	92	2	-07	-2.23 *
7 For boys	36	10	16	12	20	4.74 *
8 Power	71	6	80	6	-09	-2.06 *
9 Important	81	4	88	4	-07	-1.93
10 Destructive	40	9	25	10	15	3.18 *
11 Helps poor	66	7	63	7	03	0.59
12 Difficult	32	11	22	11	10	2.22 *
13 Easy	73	5	83	5	10	-2.40 *

* = significant differences

The English and Marathi medium percentages reveal a pattern similar to that of the total

sample. The five attributes of science mentioned most often, as seen from the above table are that science is: *interesting, useful, experimental, important for society* and *easy* as against the five mentioned least often that science is: *boring, problematic, difficult, for boys* and *destructive*. In the above comparisons, 'science is for boys' is ticked as one of the attributes of science very rarely.

There are eight significant differences in the views of English and Marathi medium students. More English medium students made negative comments about science, that is, they found science to be boring, as causing pollution, as destructive, difficult, and as for boys. More Marathi medium students on the other hand state that science is important, a source of power and is concerned with experiments.

Chapter 4

Students' drawings

4.1 Background

Children's drawings have been used since a long time to explore their ideas. The use of drawings has often been justified by suggesting that it is an adequate tool specially with very young children who are not able to express their ideas orally and in writings. But a major part why drawings hold such a sway is mentioned by Jacqueline Goodnow (1977), it is that drawings have 'charm, novelty, simplicity, playfulness and a fresh approach that is a source of pure pleasure'.

Goodnow has also pointed out that there is a belief that drawings are more 'natural' that they spring from within rather than being imitative. This might relate well with what Clive Sutton calls a 'mistrust of words'(Sutton, 1996).

Analysis of children's drawings of scientists have been popular since the classic work by Mead and Metraux with High-school students in 1957. The standard image of the scientist according to Mead and Metraux as presented by the students was of a man wearing a white coat and working in a laboratory who is elderly or middleaged, bearded, wearing glasses, surrounded by equipment and always reading a book.

The Draw-A-Scientist Test (DAST) devised by Chambers (1983) and tested on 4807 children in the age ranges of five to eleven indicated that the stereotypic images of scientists found by Mead and Metraux, were depicted by grade school children too. This study found that these images started making their appearance in the children's drawings by around the second grade and as children progressed through higher grades their drawings became more stereotypical.

The use of DAST was made in attempt to study the changes in the drawings of students (grades 4-8, n=223) whose teachers attended an intervention programme (Finson et al.) The intervention provided career information, role models, examination of sex-equitable materials and participation in innovative practices, specifically hands-on science investigation. The study had asked students to 'Draw a picture of a scientist at work', and had found that boys were more stereotypic in their drawings of scientists (male scientist, presence of eyeglasses, labcoat, funny hair, weird smile, wild eyes, beard, robotic features and scars). The posttest drawings after the intervention showed a greater movement towards less stereotypic drawings by boys.

The DAST has been widely used (Newton and Newton, 1992) as also other informal methods. According to Solomon (Solomon et. al., 1994), a reason for this being the easy methodology,

with the pupils happy to reproduce the usual images which clearly show their comic intentions. According to her asking students to draw a scientist is equivalent to asking them to start fantasizing rather than reproduce reality. Another criticism of using drawings to learn students' ideas about science is that, they provide superficial information (Boylan et. al) as compared to interviewing students to get a better description of students' understanding.

Being aware of this aspect of students drawings, this questionnaire had emphasised the aspect of drawing a scientist *at work*. It was hoped that this qualification would focus students greater on the aspect of work done by scientist and lend more credence to the activity and reduce its cartoonish aspect (Huber and Burton, 1995). However, the criticism could yet be made that even such a drawing would encourage the drawing of a stereotyped scientist, and was therefore actively encouraging the possibility of finding a stereotype. While the study did not include interviews the writing component provided more information about students' ideas.

Another problem with the drawing task is that lack of drawing ability inhibits students. In this study we assured students that we were interested in their ideas rather than how well they drew, and therefore not to worry about the aesthetics, yet some difficulty remained.

The advantage of our having used drawings is that we were able to get a more complete picture of students ideas. The questionnaire tapped various dimensions about students' perceptions of scientists and drawings were one more dimension. If we are aware of the possible limitations in the use of drawings then they can be a useful tool.

4.2 Methodology

After going through the pictures certain categories were determined and the drawings of the students were analyzed according to these categories. Two raters checked for these categories and within the two a decision could be made only with consensus. However, judgement of some of these categories is subjective. For eg., in some cases even sex cannot be judged conclusively from the drawings. Young/old or tidiness are some other such categories. Though within the team of raters (two) there was complete consensus, the rating may have been differentially done by a different team. A z test of significance of the differences in percentages reported by gender and medium of study were conducted.

The categories for analysis of drawings were

Physical attributes of the figure

1. Sex
2. Age
3. Beard, Glasses, Laboratory coat
4. Appearance of person and lab: tidy/untidy
5. Drawings of specific scientists

Attributes of science

1. Subject: Physics/Chemistry etc.
2. Laboratory: Theoretical or laboratory
3. Solitary /part of a team.
4. Equipment
5. Indoors/outdoors

4.2.1 Physical attributes of the drawn figure

4.2.1.1. Sex

The sex of the scientist drawn by the students was most often male (86.5%). Both boys and girls pictured scientists to be male. Female scientists were drawn by only seven percent of the students, and these were drawn more often by girls (10% of girls) than boys (4% of boys), this difference was statistically significant (z test 2.42, probability 0.01). With reference to medium the difference was not statistically significant though more English medium students (8%) drew female scientists as compared to Marathi medium students (4%), (z test 1.73).

That students picture scientists to be male (Barman 1997) and that the few female scientists drawn are mostly by girls is a finding that has been reported before (Chambers 1983). What however is more interesting is that younger children draw female scientists more often than do older students (Barman 1997, Newton and Newton 1992). Chambers study (1983) reported students became more stereotypical with increase in grade level and calls this stereotyped view the 'standard image of science'.

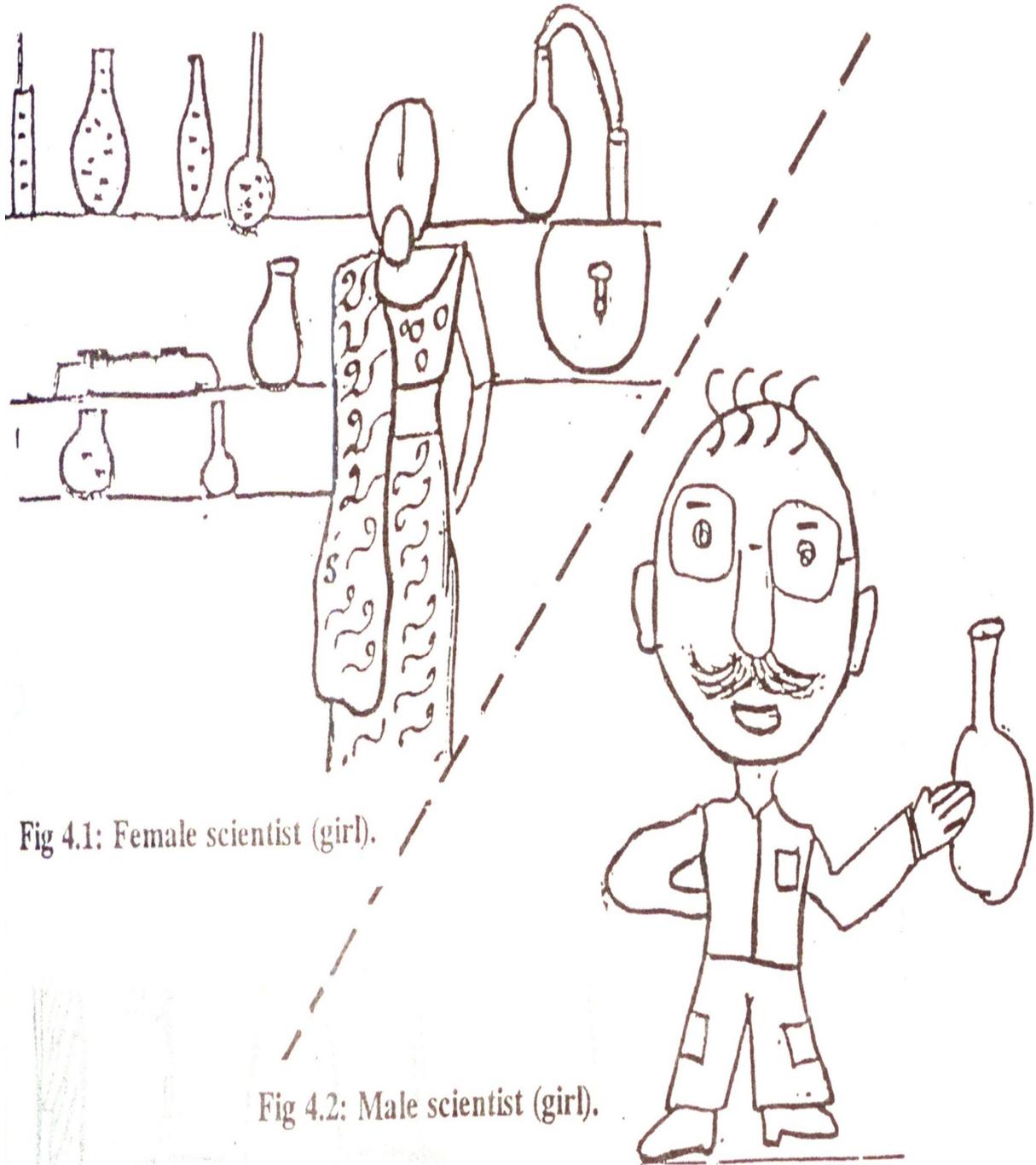


Fig 4.1: Female scientist (girl).

Fig 4.2: Male scientist (girl).

4.2.1.2 Age

Overall there were very few drawings of children as scientists, so we classified the scientist as either young (early middle-ages) or old. Overall the students perceived the scientists as being young (76%). This is also atypical of the stereotype which presents the scientist as an aging person (Mead and Metraux, 1957). Interestingly though, the Indian students when not corresponding to the western stereotype in the concept of age are actually correct. Scientists are young (Medawar, 1979).

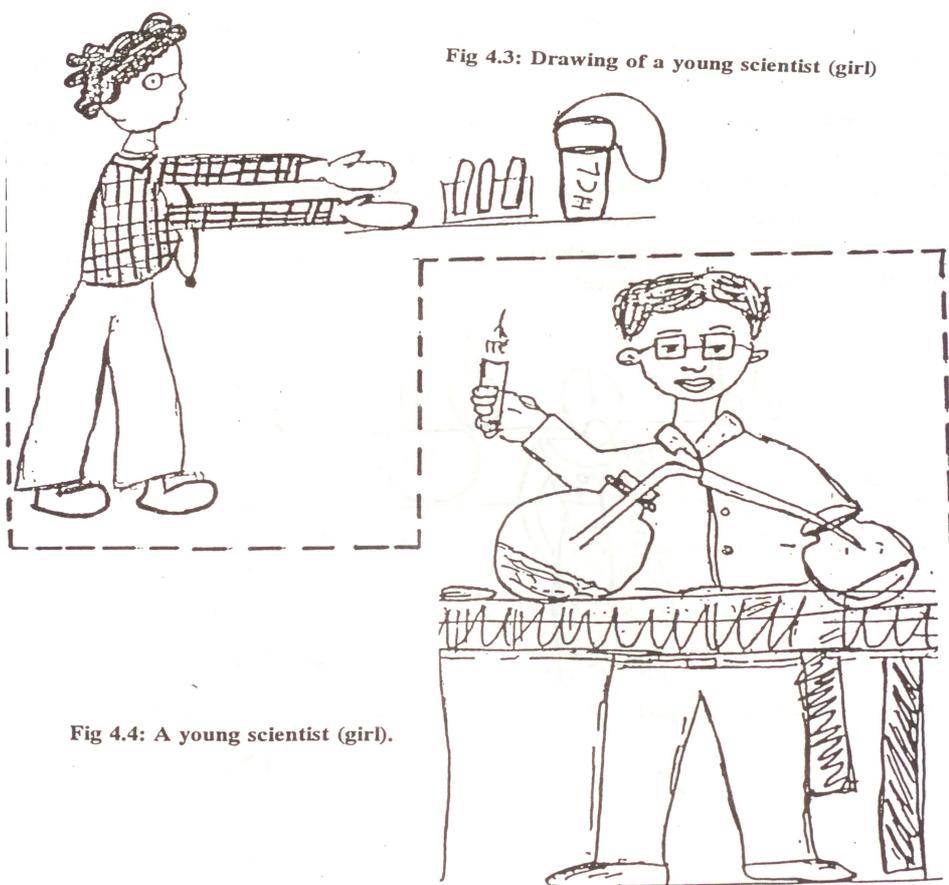


Fig 4.3: Drawing of a young scientist (girl)

Fig 4.4: A young scientist (girl).

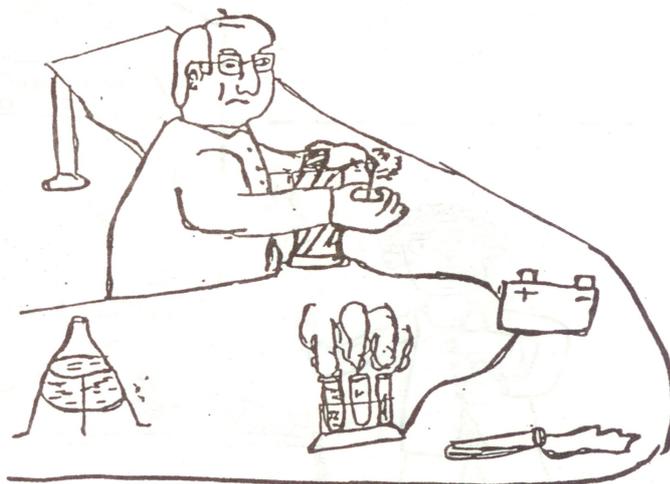
4.2.1.3 Beard, Glasses and Lab-coat

The stereotypical image of scientist often found in the literature was found to a very limited extent in these drawings. The scientist drawn was rarely depicted as wearing glasses (only 21 % of drawings), having a beard (only 8%) and wearing a lab-coat (only 9%). It is interesting to ponder over why the western stereotype of scientists is missing in the drawings of Indian students. One possible reason is that students are not as much exposed to science and scientists in the media as in the West.

Fig 4.5: Drawing depicting western stereotypical image of scientist with beard, glasses and labcoat (boy) .



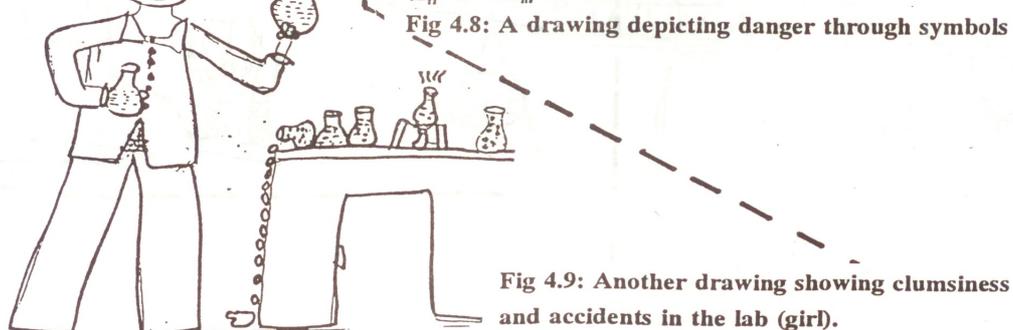
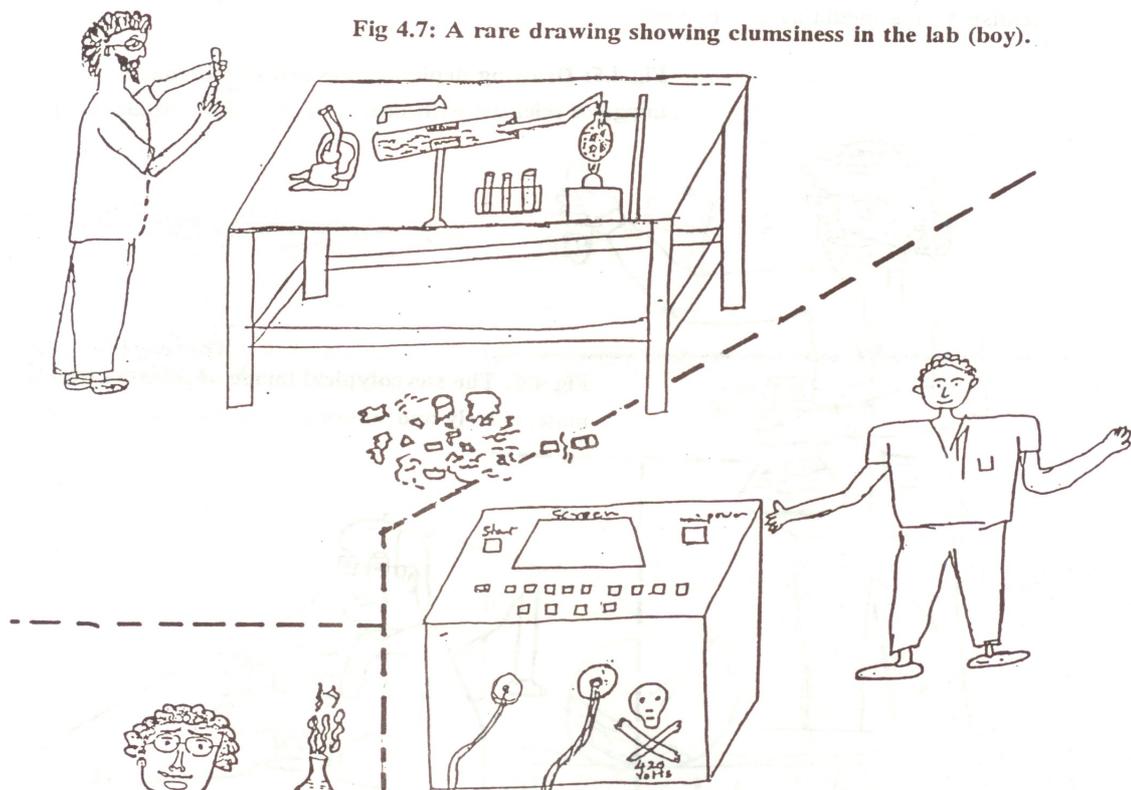
Fig 4.6: The stereotypical image of scientist who is male, elderly and wears glasses and labcoat (boy).



4.2.1.4

Appearance of person and lab

Another atypical finding as compared to the earlier literature was the depiction of the scientist as tidy in appearance of self (75%) and of his lab (74%). The drawings depicting danger and clumsiness were very few (1%). Thus, the overall positive image of the scientist that students had presented earlier in terms of neatness and other qualities in the other part of the questionnaire was depicted.



4.2.1.5 Drawings of specific scientists

Often the drawings were about some specific scientists that students knew about and these the students also either labelled or drew so accurately that there was no doubt as to who the scientist drawn represented. Some of the recognisable scientists were Newton and Edison.



Fig 4.10: Drawing of Edison (boy).

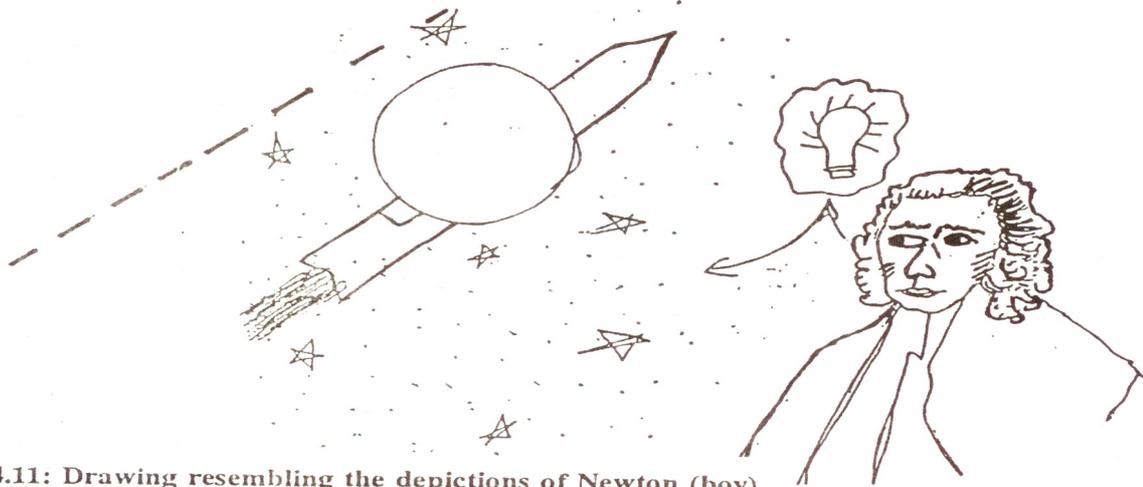


Fig 4.11: Drawing resembling the depictions of Newton (boy).

4.2.2 Attributes of science

4.2.2.1 Subject

The subject that the scientist was depicted as working on was most often Chemistry (70%). Physics (11%) was the next frequently depicted subject followed by biology, least (7%). In a few cases (10%) some conclusion could not be reached as only computers or books or mathematical symbols were depicted.

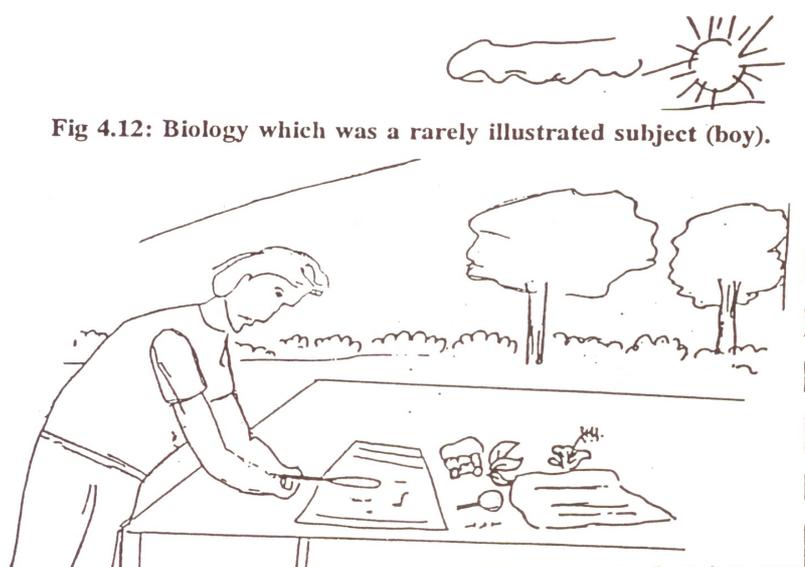


Fig 4.12: Biology which was a rarely illustrated subject (boy).

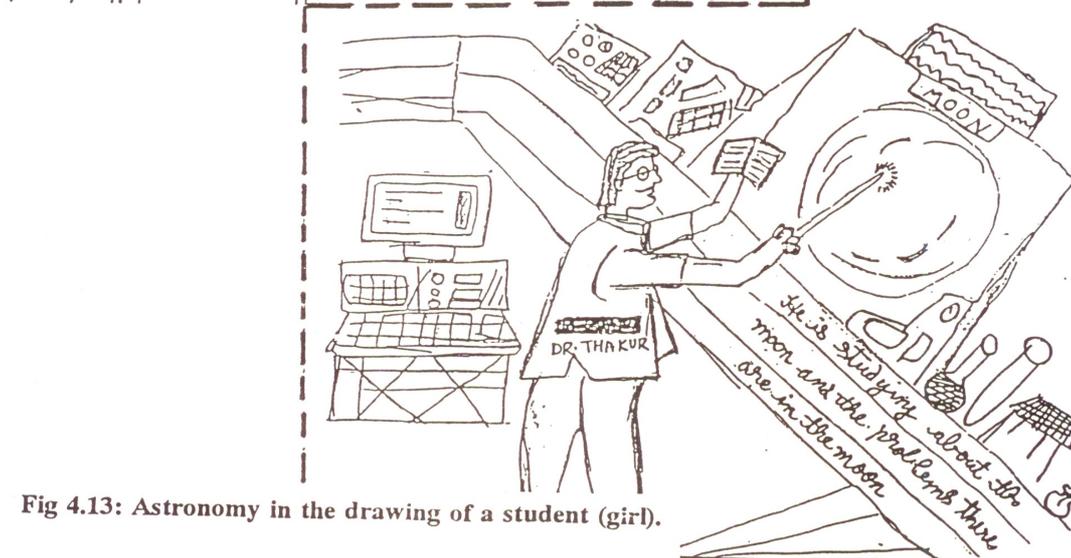


Fig 4.13: Astronomy in the drawing of a student (girl).

4.2.2.2 Laboratory / theoretical

The work of the scientist was very often seen as involving some activity in the laboratory and to that extent could be termed experimental. Purely theoretical work that a scientist could be involved in such as reading or thinking were very rare. Some drawings as the one below indicate a mixture of both theoretical and experimental work.



Fig 4.14: A scientist involved in problem solving (girl).

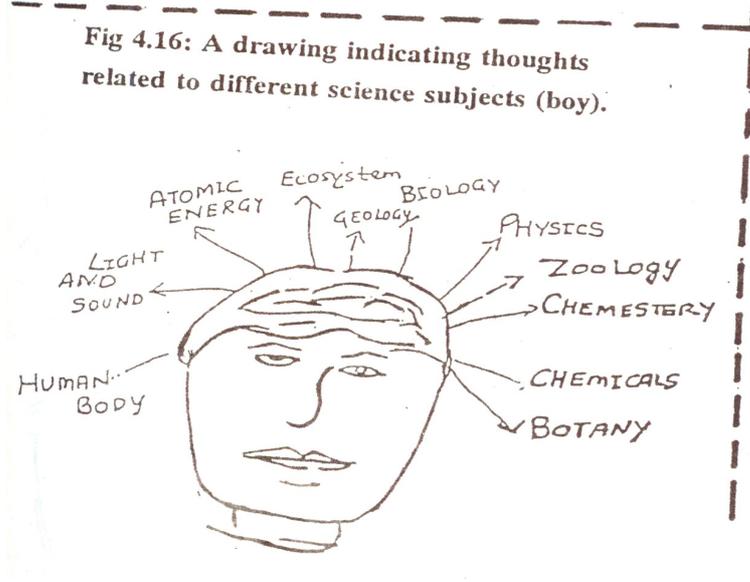


Fig 4.16: A drawing indicating thoughts related to different science subjects (boy).



Fig 4.15: A scientist thinking about experimental results (girl).

4.2.2.3 Solitary/ Group

The scientist was often drawing working alone (96%). Thus, rarely was the scientist working with some-one else (4%). When there was more than one person in the drawing the person was engaged in some totally different activity. This finding has been reported in other studies too (Boylan, Hill & Wallace, 1992) and what it implies is that science is perceived by children as an individualistic act and not a group activity.

Fig 4.17: Two scientists drawn together but involved in carrying out independent activities (boy).

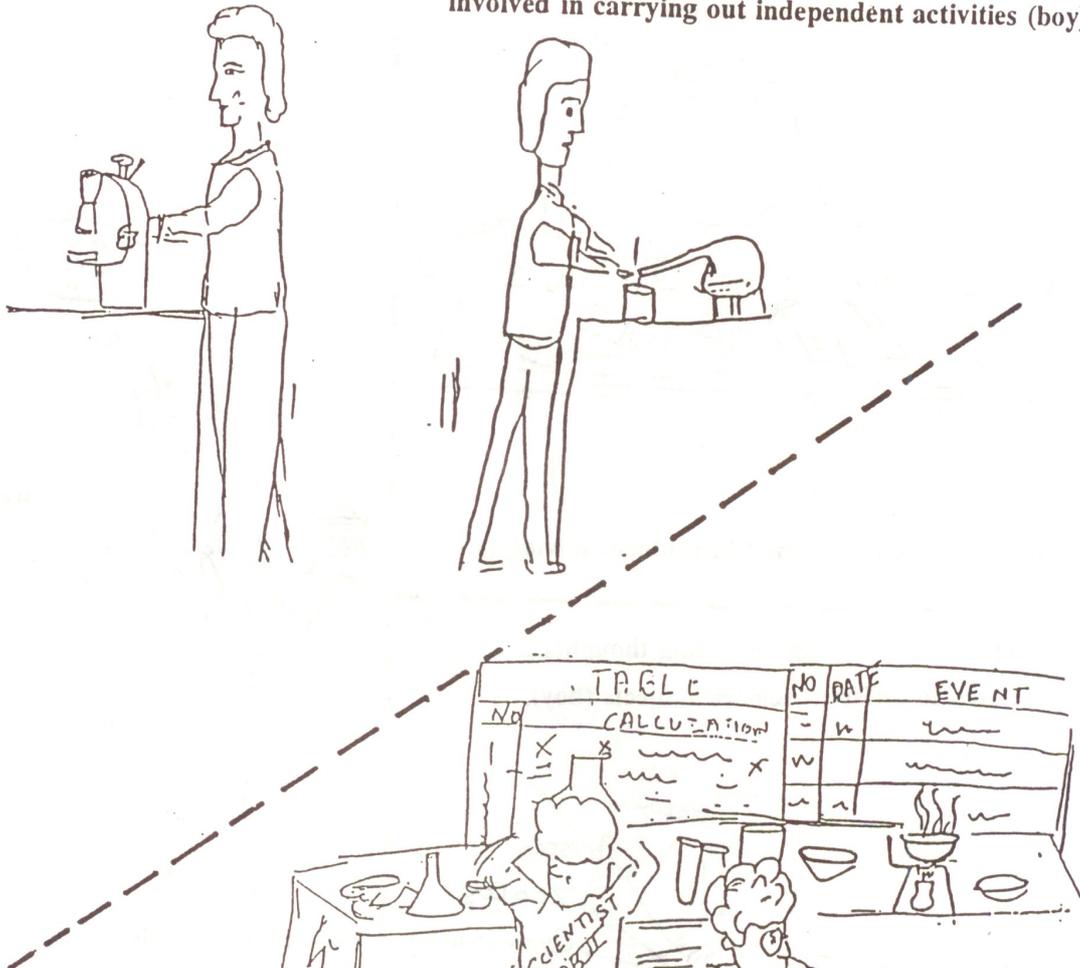
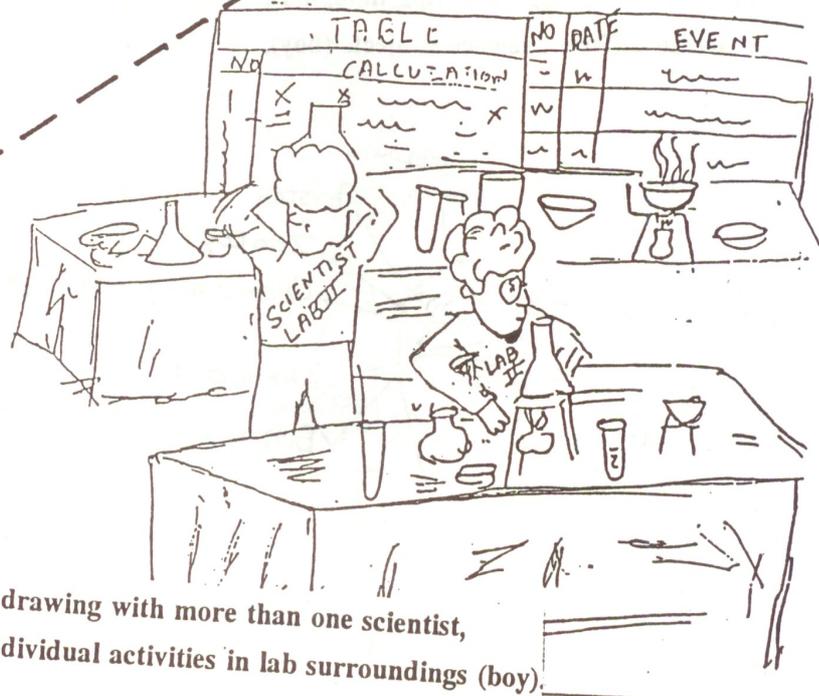


Fig 4.18: Another drawing with more than one scientist, along with their individual activities in lab surroundings (boy).



4.2.2.4 Equipment

At times, equipment dominated the drawings to such an extent that the scientist appears either robotic or another piece of equipment. In other words, such drawings would imply that science is technology oriented rather than human oriented. However, the number of such drawings were few.



Fig 4.19: Predominance of attention given to the books/library at the expense the scientist (boy).

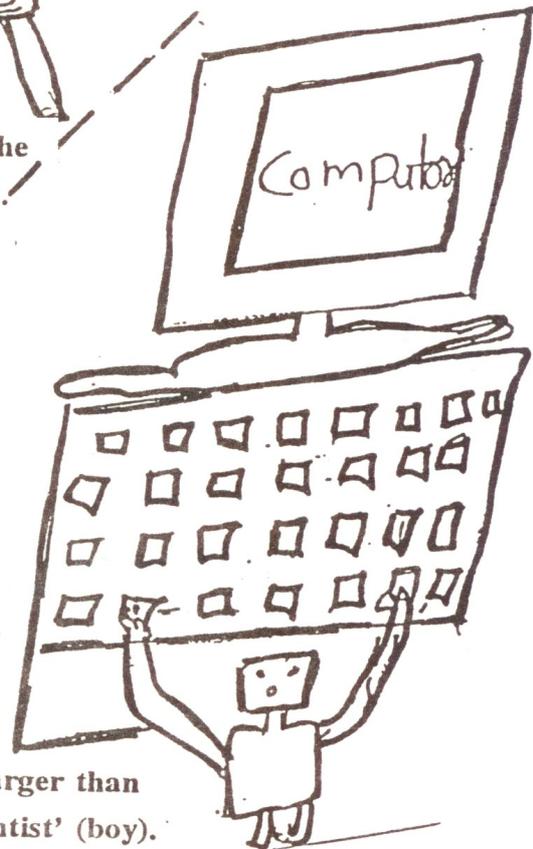


Fig 4.20: Another drawing showing the larger than life computer with the scaled down 'scientist' (boy).

4.2.2.5 Indoors /Outdoors

Very few students drew a scientist working outdoors. Thus, the image of science taking place in an already determined place is seen in the drawings. This is understandable considering that students have very little exposure to actual ways in which scientists work and hence draw upon their own experiences in the school laboratory to place the scientist as working in an enclosed space.

Fig 4.21: A drawing displaying a scientist working outdoors (girl).



4.2.3 Gender and medium-wise comparison

Table 4.1: Drawings by girls, boys, English and Marathi medium students

	Total %	English %	Marathi %	z test	Girls %	Boys %	z test
Male scientist	86.5	84.5	91	-2.00*	85	87.	-0.76
Female scientist	7	8	4	1.73	10	5	
Chemistry depicted	70	72	63	1.81	73	4	2.42*
Laboratory	79	80	76	0.91	83	67	1.38
Scientist with beard	8	10	4	2.48*	5	76	1.83
Scientist wearing glasses	21	25	10	4.17*	21.5	11	-
Wearing a lab coat	9	8.5	10	-0.49	7	21	2.38*
Tidy appearance of person	75	68	92	-6.75*	83	10.	0.13
Tidy appearance of laboratory	74	72	78	-1.35	79.5	5	-1.31
Signs of danger	1	1	1	0.00	1	69	
Solitary	96	96	97	-0.54	97	69	3.52*
Young	76	77	74	0.66	79	1	
						96	2.55*
						74	0.00
							0.57
							1.24

* = significant differences

The above table presents percentages of the various categories in the drawings of various groups of students. A z test of significance of the differences in percentages reported by sex and medium of study were conducted. There were few differences by sex. Both girls and boys equally pictured a scientist as male, young, solitary, as a chemist and as involved in laboratory work. The only differences were that girls drew more female scientists and drew scientists as more tidy in appearance and as having a laboratory neater than boys did. Boys more often drew a scientist as a bearded figure than did girls.

With respect to medium of instruction it could be seen that while in both the media students pictured the scientist as solitary and as a chemist and as involved in laboratory work, more Marathi medium students drew the scientist as male as compared to the English medium students.

Some English medium students drew female scientists. However, otherwise the English medium students fit the western stereotype better, that is, more of them think of a scientist as bearded, wearing glasses, as being less tidy about self. They also think of the scientist as older than the Marathi medium students do.

4.3 Conclusion

The drawing task definitely lent support to the fact that the term scientist evokes a male scientist in the mind of students. It also indicates that these drawings to a large extent fit the stereotype of earlier work (such as, drawing chemistry, laboratory, solitary scientist). However, the similarities faded in terms of criteria like age of the scientist (Indian students drew younger scientists) and not so many students drew beards, eye-glasses and lab-coats.

Chapter 5

Students' writings about scientists

5.1 Introduction

In the last two questions of the questionnaire, students had been asked to write about issues on which scientists work (Scientists at work) and about areas in which they themselves would like to work if they became scientists (Me as a scientist). Analysis of the writings is presented in this chapter.

For analysis of these questions, a preliminary reading of students' responses was conducted. The coding of this data was done after reading all the writings. The following categories were created through discussion between the coders (Four coders for English medium and two for Marathi medium). These codes are:

Language aspect of writings

- 1) Length of writing (in words)
- 2) Status of the responses from grammatical point of view (three sub-categories a) Above average, b) Average and c) Below average.

Reflections of science and scientists

- 3) Personal adjectives (e.g. hard-working, intelligent)
- 4) Adjective / verbs for the ways in scientists work (e.g. do research, experiments)
- 5) Gender (female, male, cannot judge)
- 6) Science as a singular or communal activity (applicable mainly to 'Scientists at work' -whether the given description is for single person or number of persons)
- 7) The subjects encompassed by 'science'
- 8) Image of science (positive, negative, mixed or can not judge)
- 9) Image of scientist (positive, negative, mixed or can not judge)
- 10) Motivations for science a) power b) money c) fame d) progress

5.2 Analysis of the data

As the categories for the analysing the data are same, the discussion about students' responses for both the questions, that is, question on what scientists do and what students would like to do as scientists is presented simultaneously. In each category, analysis with respect to medium and gender is presented first. This is followed by analysing the data for gender-wise differences within a particular medium and vice-a-versa if such analysis reveals any significant statistical differences.

5.2.1 Length of writings (in words)

The length of writings in terms of words was counted for both the questions. In general, the mean length of the writings for English medium students was significantly more when compared to Marathi medium students. For descriptions regarding what scientists do, the observed mean length for English medium students was 40.20 whereas that for Marathi medium was 18.91. The t-value for the difference in the two means was 15.85 and the 2 tailed probability was 0.00.

A similar trend was observed in response to the question 'Me as a scientist'. The mean length (63.78) for English medium students differed significantly from the mean length of writings for Marathi medium students (31.00). The observed t-value was 13.49 with 2 tailed probability was 0.00.

Gender-wise comparison for both the questions revealed that boys were significantly more expressive as compared to the girls. For the question on scientists at work, the mean length of writings for boys and girls were 41.52 and 31.46 respectively. The t-value for the two means was 2.97 with a 2 tailed probability of 0.004. For the other question, the observed mean values for boys and girls were 59.02 and 48.31 and the corresponding t-value was 2.95 with 2 tailed probability = 0.001. Table 5.1a and 5.1b show the mean length of responses for both the questions. As stated before, the lengths are expressed in number of words.

Table 5.1a: Mean length of writing for 'Scientists at work'

	English	Marathi	Total
Girls	37.78	18.20	31.46
Boys	44.20	20.85	38.17
Total	41.52	19.52	-----

Table 5.1b: Mean length of writing for 'Me as a scientist'

	English	Marathi	Total
Girls	58.00	28.62	48.31
Boys	67.93	33.43	59.02
Total	63.78	31.00	

Overall, we see that English medium students write significantly more than Marathi medium students and boys write more than girls. Within media, the same pattern is repeated that boys write more than girls. If we rank the above, English medium boys are at the top followed by English medium girls, followed by Marathi medium boys and lastly Marathi medium girls. Thus, it appears that medium is playing an important role, at the same time the role of gender cannot be ruled out.

It is rather surprising that Marathi medium students who were writing in their mother tongue were less expressive in general, even though both the stated questions presented total freedom for expression of thoughts. This raised a doubt in our minds that writing about science and scientists is perhaps a context which is not very familiar or suitable to vernacular medium students.

5.2.2 Grammatical quality

Three categories were formulated for assessing the grammatical quality of the responses. These were; below average (coding = 1), average (coding = 2), and above average (coding = 3). Overall, grammatically the writings of students were 'below average' to 'average' for both the media of instruction. The grammatical quality of writings of the English medium students was significantly better as compared to their Marathi medium counterparts.

Regarding, scientists at work, the grammatical mean for English medium was 1.86 and that for Marathi medium was 1.91. The t-value for these means was 0.64 with 2 tailed probability = 0.52. Thus, there was no significant difference between the media. Similar results were found for responses to 'Me as a scientist', where the grammatical means for English and Marathi medium were 1.86 and 1.89 respectively. The corresponding t-test value was 0.39 with 2 tailed probability = 0.70.

With respect to gender, overall the grammatical quality of writings by girls was significantly higher as compared to those by boys. For scientists at work, the grammatical means for girls and boys were 2.03 and 1.75 respectively (t-value = 4.15, 2 tailed probability = 0.00). The means for other question were 2.06 (girls) and 1.73 (boys) with t-value = 4.98 and with 2 tailed probability = 0.00. For both boys and girls, no significant differences were observed with respect to media. Table 5.2a and 5.2b display the grammatical means for both the questions.

Table 5.2a: Means of grammatical quality of writings on 'Scientists at work'

	English	Marathi	Total
Girls	2.03	2.03	2.03
Boys	1.73	1.80	1.75
Total	1.86	1.91	

Table 5.2b: Means of grammatical quality of writings on 'Me as a scientist'

	English	Marathi	Total
Girls	2.05	2.08	2.06
Boys	1.73	1.72	1.73
Total	1.86	1.89	

5.2.3 Use of adjectives (personal)

While describing topics on which scientists work, students used various adjectives. The used adjectives were categorised into two groups, namely, personal adjectives and adjectives regarding mode of working.

Overall, for question about scientists at work, 42% of sample stated one or two personal adjectives though 4% of total sample gave more than five adjectives. More adjectives were stated by English medium students (mean 2.09) as compared to Marathi medium students (mean 1.65). The t-value for the difference in the means was 2.89 and the 2 tailed probability was 0.00.

Regarding writings about 'Me as a scientist', 22% of sample stated one or two personal adjectives though about 1% of total sample gave more than five adjectives. As before, English medium students stated significantly more number of adjectives (mean 1.43) as compared to Marathi medium students (mean 1.07) with the t-value = 3.07 and 2 tailed = 0.00.

No significant differences were observed in the number of adjectives given by girls and boys for both the questions. For the first question, the mean number of adjectives stated by girls and boys were 2.08 and 1.98 respectively (t-value= 0.54, 2 tailed probability = 0.59). For the other question, these means were 1.27 (girls) and 1.46 (boys) with the t-value = 1.17 and 2 tailed probability = 0.246.

However, for writings regarding scientists at work, significant differences were observed between the mean number of adjectives given by boys from both the mediums (English - mean 2.07 and Marathi- mean 1.58, t-value = 2.26, 2 tailed probability = 0.03). It was not possible to compute similar statistics for writings on 'Me as a scientist'. No such differences were observed for girls from the two mediums. In other words, the significant differences across the two medium were due to the significantly better performance of boys from English medium. Table 5.3a and 5.3b presents the mean number of adjectives for 'scientists at work' and 'Me as a scientist'.

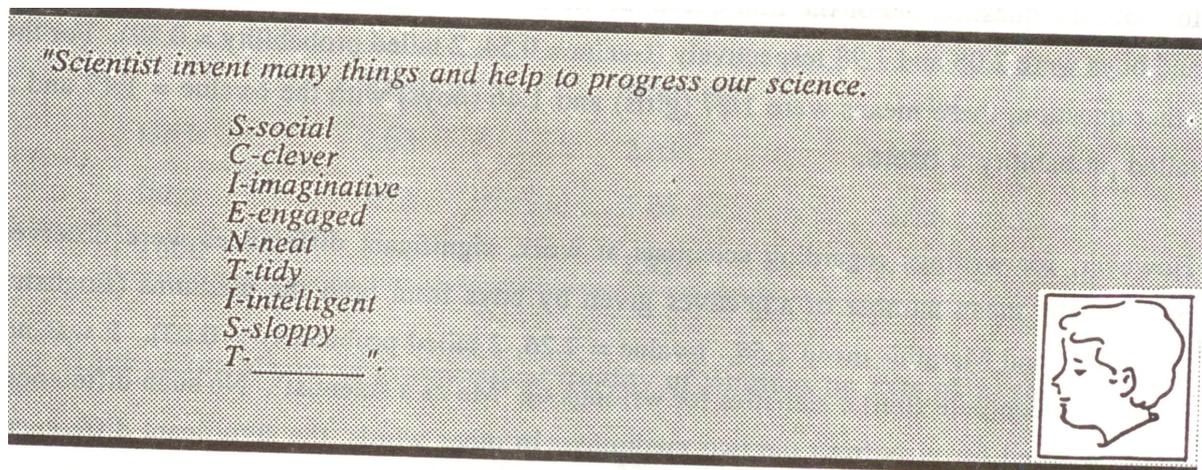
Table 5.3a: Mean number of personal adjectives used for 'Scientists at work'

	English	Marathi	Total
Girls	2.13	1.77	2.07
Boys	2.07	1.58	1.98
Total	2.09	1.65	

Table 5.3b: Mean number of personal adjectives used for 'Me as a scientist'

	English	Marathi	Total
Girls	1.28	1.20	1.27
Boys	1.55	1.00	1.46
Total	1.43	1.07	

Some of the frequently stated adjectives for the entire sample were hard-working, intelligent, imaginative, curious, helpful, innovative and devoted. Even though students used the adjectives stated in the first part of the questionnaire, all these adjectives reflect a strong positive image about scientists. An example of students' use of adjectives is given below.



5.2.4 Use of adjectives (work)

The most frequently stated adjectives about the work done by scientists were 'make', 'invent', 'explore', 'experiment', 'find', 'discover', 'study', 'observe', 'prove', 'research'. These adjectives try to capture various aspects of scientific work. All the stated objectives were

positive or neutral except one, that is, destructive, which was stated by two English medium students. Most of these adjectives were not provided in any part of questionnaire as compared to the personal adjectives stated.

Across the media comparison for writings about 'scientist at work', showed similar trends as before, that is, English medium students state significantly more mean number of adjectives as compared to vernacular medium students (Eng- 2.12 and Marathi-1.81; t-value = 2.92, 2 tailed probability = 0.00). Further, boys in the two media and girls in the same differed significantly in the number of adjectives of work (Beng = 2.13 and Bmar = 1.83, t-value =1.98, 2 tailed probability = 0.05; Geng = 2.09 and Gmar = 1.80, t-value = 2.02, 2 tailed probability = 0.045).

Such comparison for the question regarding 'Me as a scientist' did not show any significant differences (English - 1.91 and Marathi- 1.97; t-value = 0.60, 2 tailed probability 0.55). Gender-wise comparisons within media did not reveal any significant differences for both the questions.

Table 5.4a: Mean number of adjectives (work) used for 'Scientists at work'

	English	Marathi	Total
Girls	2.09	1.80	2.06
Boys	2.14	1.83	2.01
Total	2.12	1.81	

Table 5.4b: Mean number of adjectives (work) for 'Me as a scientist'

	English	Marathi	Total
Girls	1.90	1.83	1.88
Boys	1.91	2.10	1.97
Total	1.91	1.97	

A representative response from students' writings about adjectives about work is presented below:

"Scientists are those persons who do research and try to find new things. In their language, research is to see what everybody else has seen and to think what nobody else has thought. They devote their time in experimenting new things. Their motto is to try try and try till they succeed. It is indeed very exciting to eb a scientist. "



5.2.5 Gender

In many of the writings for both the questions, it was not possible to judge the gender as in these passages words such as 'Scientists' or 'they' were used. The percentages of such passages for the two questions were 89% and 83% (of total sample) respectively. However, 7% of total writings for both the questions were masculine in gender as terms like 'he' or 'his' were used in these passages.

There were few passages utilising the feminine gender. There were only 1% and 7% of such passages in the two questions. Only 1% of the total passages regarding 'scientist at work' were mixed in nature whereas no such passages were written for other question. Analysis with respect to medium and gender did not reveal any significant differences. Across the media, similar gender comparison (and vive-a-versa) also did not show any significant differences. Since the data is in terms of percentages, the z-tests was carried out for significance instead of t-tests. Table 5.5a and 5.5b presents various percentage responses of students.

Table 5.5a : Percentages responses of gender in the passages about 'Scientists at work'

	English (%)	Marathi (%)	z value	Boys (%)	Girls (%)	z value	Total (%)
Cannot judge	88	91	-0.96	87	92	-1.73	89
Male	7	6	0.39	9	5	-1.66	7
Female	1	-	1.79	-	1	-1.40	1
Mixed	1	-	1.79	1	-	1.58	1

For responses to 'Me as a scientist', comparison across the medium show significant differences for all the categories. The vernacular medium students were more expressive with respect to gender. This is primarily due to the structure of language used which makes it possible to categorise the passage with respect to gender.

Table 5.5b : Percentages responses of gender in the passages about 'Me as scientist'

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Cannot judge	96	52	-9.667*	80	86	1.66	83
Male	1	22	-5.679*	2	11	4.04*	7
Female	-	25	-6.532*	16	-	-6.09*	7

*** = significant differences**

A representative response showing the use of masculine gender in writing is produced below. In the reproduction of the actual writings of students we have not tried to correct the English of the students.

"Scientist is a person which solves problems. He is very hardworking. But sometimes he proves orthodox things wrong if also the are true. He every time work for India. Froms the formula. He is a helpful person."

5.2.6 Singular/Plural

Most of the writings were plural in nature. Terms such as 'Scientists' and 'they' were used in the passages. In writing about 'scientist at work', the z-tests did not show a significant difference for girls and boys. However, only English medium students (3%) of students used both the singular and plural in their writings. Table 5.6a presents the percentages of various writings for 'scientist at work'.

Table 5.6a : Percentage responses of number in writings about `Scientists at work'

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Plural	82	83	-0.25	84	81	-0.83	82
Singular	11	13	-0.58	12	11	-0.33	12
Both	3	-	3.13*	1	3	1.54	2
Cannot judge	1	2	-0.74	1	2	0.88	1

***= significant differences**

Like gender, for the writings about `Me as a scientist', between medium comparison revealed significant differences for all the categories. No such significant differences were observed for comparison between boys and girls. Between medium, gender-wise comparison reveals that passages by Marathi medium girls and boys were significantly more plural in nature as compared to their counterparts from English medium. See Table 5.6b and 5.6c for various percentage responses about `Me as a scientist'. There was not a single passage by Marathi medium students which was neither plural or singular in nature.

Table 5.6b: Percentages responses of number in writings for `Me as scientist'

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Plural	1	43	-9.52*	14	12	-0.62	13
Singular	78	56	4.43*	69	73	0.92	71
Cannot judge	19	-	8.61*	15	12	-0.91	13

*** = significant differences**

Table 5.6c : Between media gender comparison of number about passages on `Me as scientist'

	Geng (%)	Gmar (%)	z value	Beng (%)	Bmar (%)	z value
Plural	2	41	-6.18*	0	45	-7.24*
Singular	74	59	2.06*	80	52	4.05*
Cannot judge	22	-	6.10*	16	-	5.92*

*** = significant differences**

5.2.7 Subjects

Many subjects were stated by students in their responses to the two questions. The subject written about most in the passages about 'scientist at work' was Chemistry. It was followed by medicine, physics, biology, technology and technology in that order. The subjects mentioned rarely in the passages were ecology, earth-science, education, mathematics and the social sciences. See table 5.7a for the various responses of students for the subjects mentioned for scientists at work.

Table 5.7a: Medium and gender-wise percentage responses about subjects: 'Scientists at work'

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Biology	11	19	-2.06*	13	13	-	13
Physics	10	22	-2.98*	9	17	2.54*	14
Chemistry	17	31	-3.04*	23	20	-0.76	21
Astronomy	9	19	-2.62*	9	13	1.35	12
Ecology	4	3	0.54	5	4	-0.50	4
Earth science	3	1	1.54	1	3	1.54	2
Medicine	22	5	5.62*	14	19	1.42	17
Technology	17	4	4.76*	11	15	1.26	13
Education	1	0	1.77	1	0	-1.40	1
Social Science	2	0	2.54*	2	1	-0.84	1
Others	1	0	1.79	1	0	-1.40	1
Mathematics	2	0	2.54*	1	2	0.88	1

*** = significant differences**

Medium wise, there was a significant difference for eight subjects. Marathi medium students more often mentioned chemistry, physics, astronomy and biology in their writings. English medium students mentioned medicine, technology, social science and mathematics more often in their writings of what scientists do. In other words, it appears that vernacular medium students have often stated those branches of science which they study in regular school set ups whereas English medium students did go for some other options. Thus, the range of subjects which are included under 'science' was wider for English medium students even though these options are not very novel ones.

A similar pattern was observed for Between medium, similar gender comparison. Chemistry and astronomy was stated more often by Marathi medium girls whereas medicine, technology and social sciences was stated frequently by English medium girls. For male students, the subject physics appeared significantly in the writings of Marathi medium boys and medicine and technology appeared more frequently in the passages by English medium boys (see table 5.7b). The mention of social science specially by girls from English medium is positive since they do consider it as science. But, still the fact remains that social science is a feminine choice!

Table 5.7b : Medium-wise comparison for responses of girls and boys about 'Scientists at work'

	Geng (%)	Gmar (%)	z value	Beng (%)	Bmar (%)	z value
Physics	7	14	-1.43	13	30	-2.72*
Chemistry	17	33	-2.37*	17	8	-1.76
Astronomy	5	16	-2.20*	11	20	-1.64
Medicine	17	6	2.48*	25	3	5.73*
Technology	14	5	2.21*	19	3	4.45*
Social Science	3	0	2.02*	1	0	1.36

*** = significant differences**

With respect to gender, there was a difference in the writings of girls and boys with respect to only one subject. Boys more often than girls mentioned physics in their writings (see table 5.7a). Within media, gender comparison for Marathi medium showed significant difference for subject physics which opted mainly by boys (Bmar - 30% and Gmar - 14% ; z-value = 2.22). Similar comparison for English medium boys and girls revealed significant difference for astronomy which was preferred by boys (Beng - 11% and Geng - 5% ; z-value = 2.01). It indicates that the subjects preferred by boys are those which are viewed traditionally as Masculine choices and vice-a-versa.

Regarding 'Me as a scientist', overall the subject medicine and health was stated most often. The subjects which followed were biology, chemistry, technology, chemistry and astronomy respectively. Test of significance revealed that more Marathi medium students opted for biology whereas more English medium choose medicine and health and other subjects such as geography, archaeology for their future carries as scientists.

The gender-wise comparison presented gender differences as biology was preferred significantly by girls whereas technology and astronomy was preferred by more boys students. However, no such gender difference was observed for the most stated subject, that is, medicine and health. See table 5.7c for the medium and gender wise percentage responses for the subjects mentioned.

Further, within medium, gender comparison did show similar patterns for biology and technology. In Marathi medium, more girls selected biology as compared to boys (54% girls, 36% boys; z value = 2.07). For English medium, more boys stated technology (13% for girls, 31% boys; z value = 4.01) and more girls preferred biology (23% girl, 14% boys; z value = 2.01). This further confirms the stereotyping of different subjects.

Table 5.7c : Medium and gender-wise percentage responses about subjects: 'Me as a scientist'

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Biology	18	46	-5.71*	33	20	-3.08*	25.5
Physics	10	16	-1.64	10	14	1.30	12
Chemistry	21	21	-	19	23	1.03	21
Astronomy	15	23	-1.89	13	20	2.00*	17
Ecology	9	12	-0.91	11	9	-0.69	8
Earth science	4	2	1.21	4	3	-0.56	4
Medicine	39	25	2.56*	35	35	-	35
Technology	23	17	1.47	14	27	3.46*	22
Education	4	2	1.21	4	3	-0.56	3
Social Science	1	0	1.79	2	0	-1.10	1
Others	2	-	2.54*	1	2	0.88	1
Mathematics	1	-	1.79	1	0	-1.40	1

*** = significant differences**

The result of z-tests conducted for gender as independent variable and medium as dependent variable are presented in table 5.7d. For female students, significant differences were observed for biology and earth science. The first was preferred by Marathi medium girls whereas the later was preferred by English medium female students. Regarding boys, such significant

differences were observed for biology, technology, medicine and health and education. Only the first subject was opted mainly by boys from vernacular medium. It indicates that medium plays an important role along with gender with respect to subject selected for future carriers.

Table 5.7d : Medium-wise percentage responses of girls and boys about subjects: 'Me as a scientist'

	Geng (%)	Gmar (%)	z value	Beng (%)	Bmar (%)	z value
Biology	23	54	-4.26*	14	36	-3.37*
Earth science	6	-	2.90*	3	5	-0.67
Medicine	37	30	0.98	40	20	3.24*
Technology	13	18	-0.88	31	17	2.41*
Education	4	3	0.37	4	-	2.77*

*** = significant differences**

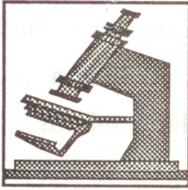
Some of the representative responses specially from the writings of students for 'Me as a scientist's' regarding various subjects are presented below. The gender of the subject is also mentioned along with the response.

BIOLOGY

Field of Biology (Rather human biology)

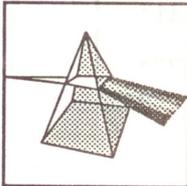
G

- Old fossils, different types of organs in human body*** **B**
- Killing of animals-concerned & like to stop it*** **B**
- Hormones, DNA structure*** **G**
- Nature and Plants*** **B**
- Human brain & cell, processes*** **B**
- Dinosaurs and methods by which they can appear again*** **B**



BIOLOGY

<i>Field of biology (Rather human biology)</i>	<i>G</i>
<i>Old fossils, different types of organs in human body</i>	<i>B</i>
<i>Killing of animals-concerned & like to stop it</i>	<i>B</i>
<i>Hormones, DNA structure</i>	<i>G</i>
<i>Nature and plants</i>	<i>B</i>
<i>Human brain & cell, processes</i>	<i>B</i>
<i>Dinosaurs and methods by which they can appear again</i>	<i>B</i>



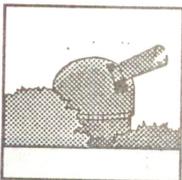
PHYSICS

<i>Make systems with highly developed electronics</i>	<i>G</i>
<i>About time (go to the future or past)</i>	<i>B</i>
<i>Electricity and current</i>	<i>G</i>
<i>How we feel in space</i>	<i>G</i>
<i>Physics - optics (optical fibres, protons)</i>	<i>G</i>
<i>Nuclear power plant, bombs</i>	<i>B</i>
<i>Invent something to save electricity</i>	<i>G</i>
<i>I want to study magnetism, electricity, weight, laser</i>	<i>B</i>



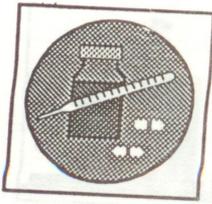
CHEMISTRY

<i>Ozone layer</i>	<i>G</i>
<i>Strong fertilizers</i>	<i>B</i>
<i>Find a substance which alchemists couldn't.</i>	<i>B</i>
<i>Chemicals and their properties, make new chemicals</i>	<i>G</i>
<i>Make chemistry interesting for teaching children</i>	<i>B</i>
<i>Invent gases like Haber, Boyle</i>	<i>B</i>
<i>I want to be like famous chemists Cavendish and Dr. Dingra</i>	<i>B</i>
<i>I would like to prepare different useful chemicals</i>	<i>G</i>



ASTRONOMY

<i>Space & creation of atmosphere on moon for living</i>	<i>B</i>
<i>Space ships, learn more about space</i>	<i>B</i>
<i>Artificial atmosphere, spaceship with speed of light, parallel universe</i>	<i>G</i>
<i>Creation of universe, its expansion</i>	<i>B</i>
<i>Travel in space in search for new life</i>	<i>G</i>
<i>Prove that Mars has life (seen by the student via telescope)</i>	<i>G</i>



MEDICINE & HEALTH

<i>Prepare more new medicines</i>	G
<i>Remedies or operations for cancer and aids</i>	B
<i>Medicine that will destroy the hunger of people</i>	B
<i>Vaccines for all diseases to be given at birth</i>	B
<i>Medicines that are not bitter, to be injected and not swallowed</i>	B
<i>Medicine to make man immortal, energetic and powerful</i>	B
<i>Cure for plague</i>	G
<i>Medicines without side effect, medicine for eye disorders</i>	G



TECHNOLOGY

<i>Mechanical equipments to make man's life more comfortable</i>	G
<i>Cameras to record & analyze voice, shoes to make travel fast</i>	B
<i>Vehicles - more power, comfort, less pollution, equipments for easy life</i>	G
<i>House which can be run on remote</i>	G
<i>Time machine- the future will be progressive phase of the country</i>	B
<i>Modern weapons- do not kill or destroy the surroundings</i>	B
<i>Gadget for a car- check pollution by filtering smoke & giving fresh air</i>	G
<i>Robot which will fight as soldiers</i>	B

5.2.8 Image of science

The most prominent observations about image of science was that there was no negative image about science at all in the entire sample. Even a mixed response, that is, both negative and positive responses was very rare (2%). As compared to English medium students, the positive image was significantly more predominant in the Marathi medium students. Between girls and boys the positive image was presented more often by girls than boys. The mixed image response and the no image responses were given more often by English medium students and boys. Table 5.8 presents all these percentage responses.

Table 5.8a : Medium and gender-wise percentage responses showing image of science: `Scientist at work`

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Positive	30	81	11.80*	54	38	-3.39*	45
No image	64	16	11.38*	43	57	2.96*	51
Mixed	2	-	2.54*	-	3	2.77*	2

*** = significant differences**

Similar pattern was observed for students writings regarding `Me as a scientist'. 49% of the total passages were positive in nature where as for 47% fell under the category `no image '. Once again, the positive image was significantly more prominent among Marathi medium students and with respect to gender, it was strongly reflected in the writings of girls. See Table 5.8b for the percentage responses about `Me as a scientist'.

Table 5.8b : Medium and gender-wise percentage responses showing image of science: `Me as a scientist`

	English (%)	Marathi (%)	z value	Boys (%)	Girls (%)	z value	Total (%)
Positive	34	88	-13.78*	43	57	-2.96*	49
Negative	-	1	-1.14	-	-	-	-
No image	63	9	14.55*	53	40	2.75*	47
Mixed	1	-	1.79	0	1	-1.40	1

*** = significant differences**

Sometimes in the given passages, it was observed that there are certain incentives for doing

science. It was possible to classify these incentives as: i) doing science brings fame; ii) science is essential for progress; iii) science gives power and iv) science for money. Whenever, science was viewed as required for progress, often students were concerned about progress of people, nation or world. But for the other three categories, students were more concerned about individual which was often self-enhancement. It is possible to view all these categories as positive or negative depending on once values. However, it appeared from students' responses that they viewed 'science' as means to achieve all the above stated goals and thus, science plays an positive role in their achievements.

The various percentage responses about passages regarding Scientists at work is presented in Table 5.8c. The z values indicate that a significantly larger percentage of Marathi medium students viewed science as a source of power. For other categories and with respect to gender, there was no significant difference for any of the stated category.

Table 5.8c: Percentage responses about science as power, fame, money and progress: 'Scientists at work'

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Power							
Yes	1	21	5.49*	7	7	--	7
No reply	95	77	4.59*	90	90	--	90
Money							
Yes	2	6	1.78	3	3	--	3
No reply	95	91	1.42	94	94	--	94
Fame							
Yes	3	8	-1.94	4	5	0.51	4
No reply	94	91	1.05	94	91	1.21	93
Progress							
Yes	46	47	-0.19	42	50	1.68	46
No reply	50	50	--	55	47	1.68	51

*** = significant differences**

Regarding writing about 'Me as a scientist', once again it was observed that significantly more Marathi students viewed science as a mean for achieving power. With respect to gender, significantly larger percentage of boys wanted to science for fame as compared to girls (Table 5.8d).

**Table 5.8d : Percentage responses about science as power, money, fame and progress:
'Me as a scientist'**

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
<i>Power</i>							
Yes	4	14	-3.07*	6	8	0.83	7
No reply	94	84	2.85*	92	89	-1.08	91
<i>Money</i>							
Yes	3	2	0.64	2	3	0.68	3
No reply	94	96	-0.91	96	94	-0.97	95
<i>Fame</i>							
Yes	10	6	-1.49	5	13	-3.03*	9
No reply	86	93	-2.35*	93	84	3.04*	88
<i>Progress</i>							
Yes	54	56	-0.38	55	55	--	55
No reply	43	42	0.19	43	42	0.21	42

• = significant differences

A few representative responses of the above motives are presented below:

A few representative responses of the above motives are presented below:



Money & Fame:

"I would like to work with the famous scientists and know about them. I like to use my talent and abilities and earn lots of money. I would like to make my own decisions and become famous."

(Boy)



Progress:

"..... I would invent new things and would make my country progress."

(Boy)

"(scientists) also help the country to progress in a rapid way.....In short, we should respect them as they are a great boon to every nation".

(Girl)



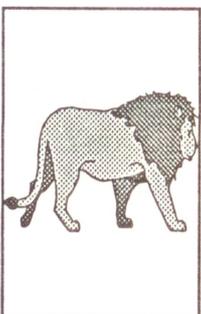
Fame:

"..I would like myself to be well-known in medicine world.....And my dream would be to achieve the post of top-most scientist."

(Girl)

"..I will try to discover more thing and I will show that I am also great."

(Boy)



Power:

" I would like to invent a thing that would help my country and destroy the enemies of my country. I would make a nuclear power plant that is helpful for the nation and also for making nuclear bombs. I would surely invent a liquid, which poured on iron would make the iron into gold and I will distribute the gold among the poor and the needy persons. I will make my nation very rich and would create fraternity between our enemies after the fight whatever the result maybe. I would bring the whole world together and if in future there would be a nuclear war, I would with my power try to end the war without any fight."

(Boy)

5.2.9 Image of scientists

Like positive images about science, overall students expressed positive image about scientists also. The percentage of positive samples in the total sample was 77 for responses about scientists at work. As before, significantly larger percentage of Marathi medium students (88%) had a positive image of scientists. More English medium students had a mixed or even a negative image of scientists. No such differences were, however, observed for gender. Table 5.9a present all these percentage responses for scientists at work.

The percentage responses for 'Me as a scientist's are presented in table 5.9b. Sixty-nine percent of the total writings were positive in nature while two percent were mixed in nature.

Table 5.9a : Percentage responses about image of scientists: 'Scientists at work'

	English (%)	Marathi (%)	z value	Girls (%)	Boys (%)	z value	Total (%)
Positive	73	88	-3.94*	78	76	-0.5	77
Negative	2	-	2.54*	1	2	-0.9	1
No image	13	9	1.27	14	11	-0.9	12
Mixed	10	1	4.73*	5	9	1.7	7

* = significant differences

Table 5.9b : Percentage responses about image of scientists 'Me as a scientists'

	English (%)	Marathi (%)	z value	Boys (%)	Girls (%)	z value	Total (%)
Positive	60	90	-7.84*	69	67	-0.45	69
Negative	-	1	-1.187	-	-	-	-
No image	34	8	7.25*	24	30	-1.41	27
Mixed	3	-	3.13*	3	1	1.54	2

* = significant differences

5.2.10 Styles of writings

Various styles of writings were found in the passages of students. Sometimes, students presented expectations from scientists instead of what scientists do. Two representative examples are:

5.2.10 Styles of writings

Various styles of writings were found in the passages of students. Sometimes, students presented expectations from scientists instead of what scientists do. Two representative examples are:



"scientist should have a working mind. He should all the time be active. He should be hard working and....."



"A person having a scientific aptitude should go to such a profession. He should research on those subjects on which no research has been done till now. He should have the curiosity of studying more books and observing carefully. He should not jump to conclusions"



Sometimes a writing style depicting fantasy was used. This was more common in the writings of 'Me as a scientist'. One such example is -



"My world is my laboratory. It's a paradise for me..... My aim is to bring my country's name in the list of toppers....."



Sometimes the style used was autobiographical, for example,



" From my early age, I used to think that when I will grow up I will become scientist. And that time has come and I am a scientist. It is very interesting to work as a scientist.... And today I also had made a phone by my own hand"



"When I was small, I used to do small experiments in school and I would discover something new.Now I am big. I have succeeded. I have become a scientist.....My experiment worked and I became famous.....Now I am old...."



Some writings discussed specific problems related to India :



"If I were a scientist I would like to do research on water. Nowadays contaminated water is supplied. I would like to take samples of different kinds of water and take out their impurities and make sure that everyone is getting healthy water. Thus, at least one problem which India is facing can be cleared"



As observed in case of drawings, specific names of famous scientists such as J.C. Bose, Newton, C.V. Raman were stated in the passages and sometimes a desire to become like them was also expressed. Some more passages presenting various images of scientists and science are presented below.



"Scientists are the people who just think and don't do anything. They just think over the experiment and don't do anything. They are selfish and just want to be famous. They don't care for people sometimes. They don't want to express their ideas and opinions. They just want to make their names."



"I think that scientists have done a spectacular job in exploring various things of nature. It is only because of the scientist that we are able to know various parts of our own body and many other things."



"If I become a scientist I would always try to discover things which are always a '?' in the minds of students. Mainly I would like to discover more about how a child is born? What changes take place in the body of a woman at that time? How does a child develop in the stomach? These things have always been in my mind as big thick questions."



5.3 Conclusions

Various aspects about students' writings regarding *Scientists at work* and *Me as a scientist* are presented in the chapter. With respect to lengths of passages, medium played an important role. The responses of English medium students were significantly longer. For the grammatical quality, responses by girls were significantly better as compared to boys for both the media, though overall the quality was mostly average. Most of the passages about scientists at work were plural in nature. The subjects appeared most in the responses were chemistry, medicine, physics, biology and technology. Here once again it was observed that English medium students mentioned more subjects as compared to vernacular medium students. Gender differences were observed for physics and astronomy as both were stated and opted more often by boys than girls. Further, biology was preferred by girls for their future carriers. These responses presented a strong positive image of science and scientists in general. This positive image which was reflected by both the gender was, however, stereotypical in nature. Thus, in short, scientists were viewed as those intelligent and hardworking people who search new things or do research and experiments and their work, (that is, science) leads to the progress of world/people.

Chapter 6

Conclusion

6.1 Overview

This study used a multi-task approach to gain insight into students' ideas about science and scientists from various perspectives. These multiple tasks not only tapped differing aspects related to an image of science and scientists but also required students to use different skills ranging from merely checking, to writing essay type answers and drawing.

The various tasks drew upon students' ideas about scientists as persons, the very many possible 'out of school experiences' that students may have, what students may like to learn more about in science, what students consider important for a future job, their views about science in action, their drawings of scientists at work, their writings about what issues scientists work on and what they themselves would work on if they became scientists. The multiplicity of tasks aimed at obtaining a comprehensive and balanced view of students' perceptions.

The study was conducted with eighth standard students who are approximately 13 year old. This is a crucial year for many reasons. In Mumbai where the data was collected, the weightage of science in terms of marks in schools increases this year. Practical sessions for students are also introduced in the syllabus around this time. Students are approaching the stage where they will have to make decisions about the future, in terms of continuing studies and the choice of specialisation. These decisions will determine whether students continue in science or not. At this stage of life image of a subject may play an important role in decision-making.

The work was conducted in classrooms and the gender breakup of the sample reflects the existing gender patterns in schools. The study was conducted in scholastically average schools from two media of instruction namely, English and Marathi (which is the state language).

The findings of the study confirm various earlier findings in the area. Other results of the study however, are more specifically related to the Indian context. The findings related to gender and media of instruction throw some light on the existing scenario and also provide inputs into the framing of science syllabus.

6.2 Summary of results

One of the most consistent findings from all the tasks set before the students, was the overly positive image of science and scientists that strongly emerged. That students have such a positive image of science and scientists may be viewed as a favourable manifestation in a developing country like India which since its Independence has emphasised science and technology for development.

This finding that students hold a very positive image of science and scientists has been reported by very many earlier studies in the West also (Mead and Metraux, 1957). However, some recent studies have brought out that students point out the destructive and harmful aspects which they associate with science, and hence they do not hold a glorified picture of science (Solomon et.al, 1994).

Though students hold a very positive image of science and scientists, this image is a stereotyped one. Stereotypes are restrictions or narrowing down of roles, characteristics or qualities. In this study, it was found that most students perceived scientists to be a young, intelligent, hardworking male, who is a solitary person and is engaged in laboratory work which is most often chemistry. Biologists were viewed as neater, more caring, social and kinder (biology as a caring subject) than the physicists, who were viewed as more intelligent, imaginative, hard-working, interesting and democratic (physics as a brainy subject). This stereotype of science and scientists matches the ones reported earlier (Sjoberg and Imsen 1988). In this connection, it is necessary to mention that girls reported many more biology options under the 'Me as a scientist' writings while boys stated many more astronomy and physics options.

However, some other aspects of the reported stereotypes were not very commonly found in the study. It is interesting that Indian students did not often draw scientists as old, with a beard, wearing glasses and a labcoat. This image is closer to reality than the Western stereotype of a scientist. One probable reason for the same could be that the media in India is not giving exposure to science and scientists to a large extent. Hence, these stereotypes which are generally presented by the media in other countries are lacking. The laboratories drawn were also neat and tidy in appearance, rarely showing signs of danger and accident. This is perhaps another indication of the perfection of scientists.

There were no gender differences in the above perceptions. Most girls and boys had similar views about science and scientists. That science is a male activity and scientists are males was held by both girls and boys. However, drawings of female scientists (which were very few) were drawn only by girls. When asked about science in action, less girls stated that it is 'for

boys'. These differences are statistically significant and thus, indicate that at least some girls in the study see science as holding some opportunities for them. In other words, the overall image of science and scientists reflects the existing situation, but not the changing scenario ahead. The fact that some girl students despite the constant bombardment of stereotypical images of science and scientists as a male domain manage to break free from the stereotype suggests that even a few inputs into the educational system may help in bringing the desired changes.

6.3 Implications for curriculum

In connection with students 'out of school' experiences, many differences were found by media and gender. Of the 80 activities provided to students, more of the activities were done by boys and English medium students. The kinds of activities done by Marathi medium students and girls were restricted not only by number but they differed with respect to the range. The activities reportedly done more by girls were related to home and kitchen while the activities done by boys ranged from use of tools and equipments, making something and nature and environment.

Most of the activities presented to students can be related to school science and often serve as the starting point for teaching science. In other words, knowingly or unknowing teaching science in school is a more familiar context for boys and English medium students. Thus, to certain extent such a science may reduce opportunity for classroom interactions for some students and thus their interest in the subject.

A supportive evidence for this claim comes from the fact that Marathi medium students who were writing in their own mother-tongue and therefore should have been at an advantage were in fact less expressive in their writings. The lengths of the passages written by the vernacular medium students, as well as their use of adjectives and subjects mentioned by them was much less. This implies that perhaps science as a subject is detached from the daily lives of some students.

There is a need to include topics and activities that are interesting or have a basis in the experiences of most students. However, it is not enough to merely replace one activity by another but there is a need to change the organizing principles of the topics, as has been pointed out by Sjoberg and Imsen (1988). Another repeatedly pointed out aspect of school education is the rampant gender bias of textbooks (Kalia, 1986). Though there are some attempts at alleviating the same in Indian textbooks, the condition of the present textbooks is not very satisfactory in this regard yet.

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