AN EVALUATION OF PRACTICAL WORK AT INTERMEDIATE STAGE IN BIOLOGY IN PAKISTAN WITH SPECIAL REFERENCE TO SCIENCE PROCESS SKILLS

by

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ABSTRACT

This study investigates the extent to which the processes of science are in evidence in the practical work of Intermediate Biology courses in Pakistan.

Analysis of the officially prescribed practical guide shows that most of the investigations are at Level One of inquiry, while in the more popular guides - written by Pakistani writers - most investigations are at Level Zero.

Lecturers' responses in questionnaires and interviews show that, except for observation skill, their priority is for content and not for process skills, and that has been found to be consistent with systematic observations made of their practices in laboratory classes. The textbook used on the course does not noticeably affect the lecturers' responses. Students are found to value their practical work in Biology for catering for content to the exclusion of process skills.

The eight science skills judged by lecturers as being those which their students perform most skilfully were established. Criterion-referenced test on a random six of these were developed and students tested. Results show the limited number of students reaching competency in each skill, including observation. However, in every case more students reach the level for competency in colleges using the prescribed practical guide, and significantly more reach competency in a greater number of the skills, than amongst students in colleges using other texts. An explanation for this result is suggested.

The form of the practical examination is found to be a major factor in determining the lecturers' priorities and practices.

Evidence is presented in support of an alternative form of practical assessment as being likely to be effective in serving to focus attention on the processes of science and cause students to develop them, in this way helping to meet the requirement laid down in the current policy statement for science education in Pakistan.

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CHAPTER 1

INTRODUCTION

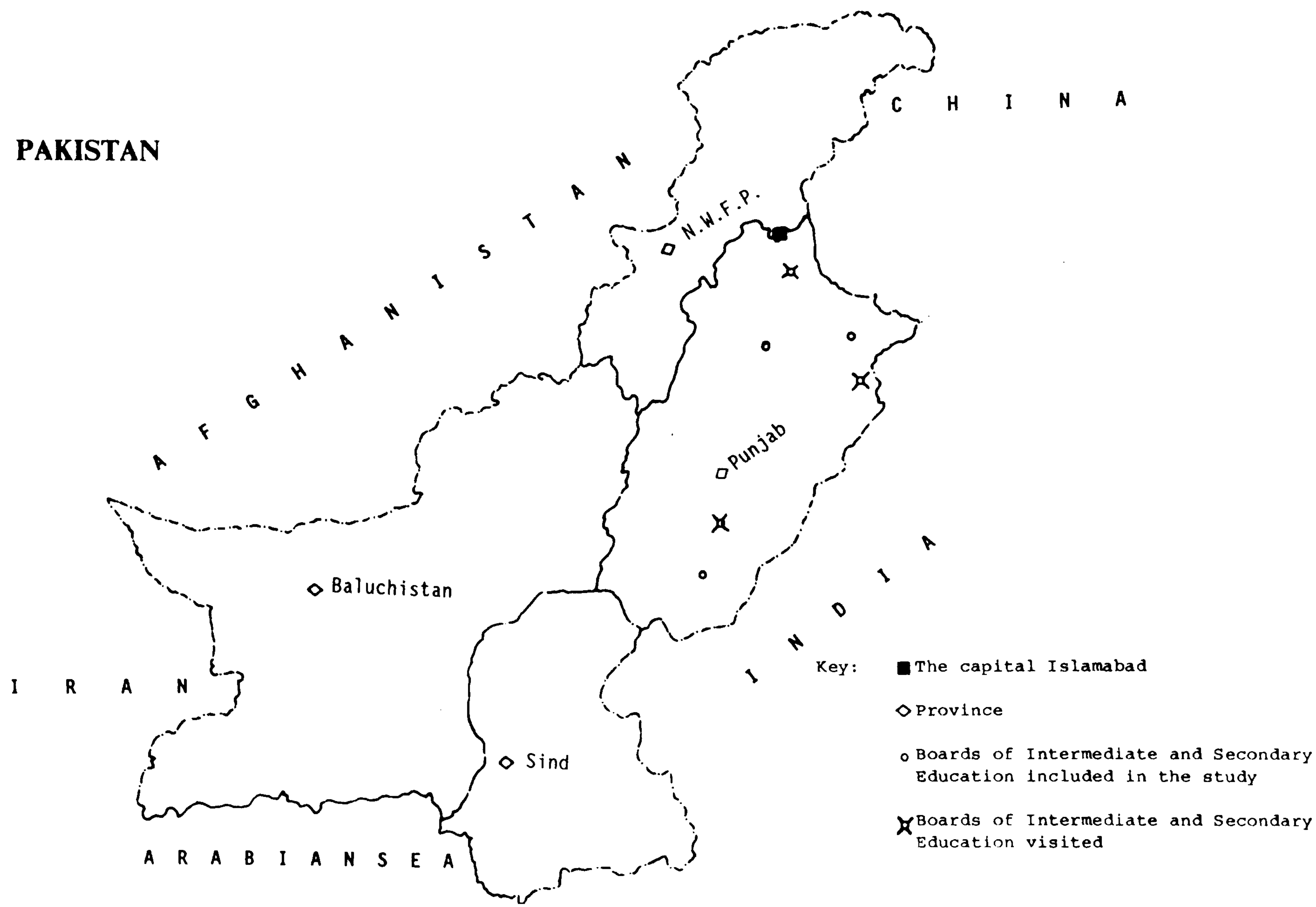
1.10. Pakistan: A general background of the country

Pakistan is an independent muslim state in the sub-continent of Asia. In 1940 muslims of the sub-continent proclaimed their separate nationhood. In 1947 the sub-continent was divided into two separate, independent states. Areas with muslim majority were declared as Pakistan and those with hindu majority were declared as India.

1.11. Area

At the time of independence Pakistan formed two geographical units, namely: East Pakistan and West Pakistan, separated by about 1600 km of Indian territory. In 1971 the east wing of Pakistan separated and became an independent muslim state Bangladesh.

Now Pakistan has four Provinces namely: Punjab, Sindh, Baluchistan, North West Frontier Province, besides Federal capital and Federally administered areas. The capital Islamabad lies in the north. Pakistan has an area of approximately 80500 sq. km. Boundary lines of Pakistan join with India, Afghanistan, Iran, China and Russia (see map).


PAKISTAN
AFGHANISTAN
CHINA
IRAN
INDIA
ARABIANSEA
N.W.F.P.
Punjab
Baluchistan
Sind
Key:
The capital Islamabad
Province
Boards of Intermediate and Secondary Education included in the study
Boards of Intermediate and Secondary Education visited

1.12. Population

According to the census report of 1981 Pakistan has a population of 83.6 millions. Population growth rate is 3 % per year (Government Report (1982)). Three quarters of the population lives in rural areas and only one quarter of the population lives in Urban areas (Ibid.). Pakistan is a country with a muslim majority. Ninety-seven per cent of the population is muslim and the remaining three per cent of the population is comprised of Ahmadis, Christians and Hindus (Government Report (1982)).

1.13. Literacy and Languages

Pakistan has a literacy rate of 23.3 % in 1981 which is the lowest among developing countries. The male literacy rate is 31.8% while the female literacy rate is only 13.7%. (Government Report (1983a))

Literacy ratio varies widely for urban and rural areas (see Table 1.1). In the rural areas the literacy rate is extremely low. Several factors contribute towards this but in particular the lack of educational facilities, economic problems, due to which children start working at a very young age and are thus deprived of education, and lack of motivation particularly among girls, are the major factors (Government Report (1983)).

Table 1.1. Literacy rates in Urban and rural areas of Pakistan

Province	Literacy Rates Urban	Rural
Baluchistan	27.9	04.4
N.W.F.P.	32.1	10.9
Punjab	43.1	17.3
Sind	46.8	12.7

Source: Census Report 1981

Pakistan has several regional languages which are spoken and used in educational institutions at primary school level in the respective regions. However, the National language is Urdu and efforts are being made to introduce Urdu at all levels of education as well as in offices as the official language.

English is still widely used in official and legal transactions and also in higher education as a medium of instruction; particularly science is taught in English from college to university level.

Table 1.2. Province-wise literacy rate and population in percentage.

Province	Population	Literacy Ratio Female	Male
Punjab	58	14.4	35.5
Sind	22	19.1	36.0
N.W.F.P.	17	4.9	27.7
Baluchistan	3	2.9	12.5

Source: Census report 1981 Pakistan

1.14. General Economy

Pakistan is mainly an agricultural society, one in which agriculture is a major sector of economy and plays a vital role in the economy. Agriculture contributes 29.7% to GNP (Government Report (1982)) besides providing a livelihood for the majority of people in the country, absorbing 55% of the labour force (Government Report (1982)). The raw materials requirement of domestic industry, such as jute and cotton, is also fulfilled to a great extent by agriculture. Wheat, rice, sugar cane and cotton are the major crops of the country.

At the time of independence in 1947, Pakistan had hardly any industrial base and the basic infrastructure facilities were not well developed. Technically skilled manpower and other essential requirements for industry were also very limited. The share of manufacturing sectors in the GDP (Gross Domestic Product) was as low as 7.7% in 1949-50 (Government Report (1982)). Over the years, this sector has been considerably expanded and developed. Now, after Agriculture, it is the second largest sector of the national economy.

The mineral sector's contribution has been relatively small in the GNP. Insufficient geological mapping at an appropriate scale, lack of exploratory equipment and shortage of trained and experienced manpower have been the main causes of constraint in the proper exploitation of mineral resources.

1.15. Labour Force

Unemployment rate in Pakistan is 3.5% (Government Report (1983)) which is very low among the developing and the developed countries. Emigrating labour force to Middle East countries, low rate of female participation and under employment in agriculture are the main causes of low unemployment rate.

Since 1951 the size of the civilian labour force has increased progressively from 3.9 million to 26.06 million out of the total population of 88.22 million (as in January 1983).

1.20. The education system

The role of education as a vital national investment has long been recognised in the country. There have been consistent efforts to improve the education system and to introduce compulsory education. Until today education is not compulsory at any stage, rather it is more a matter of parents' preference whether or not to send their child to school. The children who are enrolled in schools are also not obliged to continue their studies. Ever since the independence efforts have been made to institute compulsory education. In the latest educational plan (1983-88), it has been planned to introduce compulsory education at primary school level by the end of plan period i.e. by 1988 and then gradually to extend it to secondary school level during the next plan periods (Government Report (1983)).

The education system of Pakistan has been through many changes since independence. At present the education system in Pakistan is a four-tier system namely:

(i) Primary Education

(ii) Secondary Education

(iii) Higher Secondary Education

(iv) Higher Education.

Each of these 4 tiers have more than one stage. Promotion from one tier to the other and one stage to the other is based on the marks obtained either in the public examinations or in the case of promotion from one stage to the next, in examination, held by the school or college.

1.21. The Primary Education (age group 5 to 10+)

It is the first tier in education. A child enters a primary school at the age of 5 years. The primary education is comprised of four-stages or grades namely: I, II, III, IV and V. At present, promotion from one grade to the next is based on performance in examinations set by the schools. In future plans, it has been decided to promote a child from grade I to III without such examinations.

The purpose of this proposed change is to encourage pupils and decrease drop out rate. At present 50% of the students who enrol in the first grade drop out by the time they reach class five (Government Report (1984)).

A hard core of subjects is taught at this stage including, Mathematics, language, General science, Islamic studies and Pakistan studies. In future, in the first three grades emphasis will be given to reading, writing and arithmetic. Science and other subjects will be an integral part of reading and writing. The medium of instruction in state schools at this level is Urdu.

Some of the major problems faced in primary education are a very high drop—out rate and a low enrolment. These problems have been attributed to both in school and out of school factors, namely: general poverty, low motivation of rural people to send their children to schools, uninviting rural conditions and socio-economic and cultural inhibitions towards the education of female. These are said to be responsible for inability to achieve the target of universal primary education. In schools poor conditions of school building, lack of equipment and teaching staff and aids, low morale of teachers and their harsh treatment towards pupils, unattractive curriculum and environment, and absenteeism among teachers are the major discouraging factors (Government Report (1979)).

At the primary stage a National curriculum is followed, each Province publishing its own text books for the curriculum. A national teaching kit has been developed, written in Urdu, the national language, and is provided to each school, but mostly the teachers do not use it.

Science was not compulsory at this stage before the 1960s but in 1960s it was introduced as compulsory subject.

At the primary stage science is taught as General Science. The general Science course of primary classes is based on teaching under three major headings, namely: Living Things, Matter and Energy, and Earth Science.

A teaching kit and a guide for teachers are provided to schools for teaching science and mathematics. The purpose of the teaching kit is to use a minimum of chalk and talk method of teaching and to introduce teaching methods based on students-centered activity in which students learn by doing simple activities and observing objects, phenomena, plants and animals.

Recent surveys have shown that by and large these kits and their teachers' guides are not put to much use (Government Report (1984)).

1.22. The Secondary Education (age group 11 to 15+)

The secondary education is comprised of five stages namely: grade VI to X inclusive. A student enters the secondary stage at 10+ years of age. The entry requirement for secondary stage is pass marks in the primary school certificate examination.

Two types of schools, cater for the secondary school stages namely: middle schools and high schools. Middle schools cater for grade VI, VII and VIII while high schools cater for all five stages of secondary education. The stages from grade VI to VIII inclusive are often referred to as middle stage.

All government schools follow the national curricula in secondary classes. Each Province has its own text-book boards which develop and publish text- books according to the prescribed curriculum. The medium of instruction is Urdu in state schools.

At the secondary stage the curriculum is comprised of a hard core of compulsory subjects namely: languages, Mathematics, General Science, Pakistan Studies, Islamic studies Health and Physical education and Arts, Agrotechnical studies, Home Economics (for girls only), tree plantation or manual work.

It is important to note that at this stage there is no practical work in general science and the subject is taught only theoretically.

At grade IX and X the scheme of studies is comprised of 4 major components:

Component 1 is compulsory for all students and is comprised of four subjects namely:

English
Islamic Studies
Pakistan Studies
Urdu

Component 2 is comprised of three groups of subjects. The students have to choose one of these groups of subjects which are as follows:

A. Science Group:-

This group includes 4 subjects namely: Biology, Chemistry, Mathematics and Physics. The students who opt for this group have to study all four subjects.

B. General Group:-

This group includes a number of subjects from which the student has to choose and study four subjects, one of which must be chosen from group 1 and two from group 3. Group 2 is obligatory. The subjects offered under this group are as follows:

Group 1

A. Elements of Home Economics
B. General Mathematics
C. Household Accounts and Related Problems
D. Mathematics

Group 2 - General Science

Group 3 - The student has to choose subjects from a range of 36 subjects offered in the field of Economics, History, languages, literature.

C. Vocational Group:-

This major group of subjects includes sub-groups of subjects in the field of Agriculture, Commerce, General vocational subjects and

Industry. A student who chooses to study this group of subjects has to choose one of these areas and then within the general area he/she has chosen again a choice of subjects is given. Depending upon their choice the students has to study one or more subjects in the area they have selected. For instance if a student chooses general vocational subject he/she will study one subject from a list of subjects offered, while in the case of Commerce the student will have to choose two subjects again from a list of subjects.

In grade IX and X (age group 14 to 15+) science-group students and those students who opt for vocational subjects are required to carry out practical work as a component of syllabus. This is their first experience in science laboratory, practical component is included in the final assessment in the promotion examination. At present there are 4221 high schools out of which 1600 are located in the rural areas and in these schools science laboratory facilities are virtually non-existent (Government Report (1984)). Performance of practical work and its inclusion in the final assessment is dependent on whether or not the school has laboratory facilities.

At the end of academic year grade IX students sit an annual examination held by the school and the promotion from grade nine to ten is based on performance in this examination.

At the end of grade ten a public examination is held by the Board of Intermediate and Secondary Education. Those who pass are awarded a Certificate of Secondary School Education.

Secondary stage of education constitutes an important vertical link with other tiers of education (see Flow chart 1). It also provides the training ground for a substantial number of students who do not reach the college level and have to be absorbed in the economy. One of the reasons for providing a broad range of subjects at this stage is to cater for the needs of all students.

The scheme of studies at secondary school is intended to ensure ready assimilation of the youth in the world of work (Government Report (1984)).

1.23. The Higher Secondary or Intermediate Education (age group 16 to 18+)

After completing their Secondary school education the students who remain in the system either join certificate courses for primary teachers or technical teachers, or join diploma course in agriculture or technical education or enter into this third tier of education, that is Intermediate education. The students who join the Intermediate tier are 16 to 18+ years of age.

As the name suggests, in the present system this tier of education is an intermediate stage, or link, between Secondary schools' education and the Degree courses. In the present system it is a crucial tier. As is apparent from the flow chart 1, a Certificate of Intermediate Education, which is awarded to successful candidates after the completion of this tier, is an essential prerequisite for many professional and general Degree courses and it is also essential for those who want to join Certificate of Teacher Training courses.

Thus the Intermediate education is a crucial stage for students. On one hand (in the present system) it is a preparatory stage for many professional and general degree courses, on the other it is a terminal stage for many students who leave the system after Intermediate. For these reasons it has to be broad-based, flexible and of a high quality.

Each province has its own Text Book Board, Bureau of Curriculum and Research and Examining Boards for Intermediate and Secondary Education. The Examining Boards develop their own scheme of studies according to the National curricula and the Text Book Boards develop adapt or adopt text books. The provincial Boards and Curriculum Bureau work in close collaboration with the National Bureau of Curriculum and Text Books based in the capital. The National Bureau of Curriculum and Text Books review the syllabi and text books prepared by the provincial Bureau of Curriculum and Text Book Boards.

At present, Intermediate classes are based in two types of institutes namely: Degree colleges and Intermediate colleges. Degree Colleges cater for Bachelor's degree classes (i.e. B.A. BSc. coursesas well as for these Intermediate courses, while Intermediate colleges cater for only Intermediate courses.

The present scheme of studies for Intermediate classes includes a hard core of 4 compulsory subjects namely: (i) English, (ii) Islamic Studies, (iii) Pakistan Studies and (iv) Urdu.

In addition it has 12 groups of subjects in the field of science, commerce, technical and vocational education, and humanities. The students have to study one of these 12 groups of subjects according to their choice. The 12 groups are as follows;

1. Agriculture
2. Commerce
3. General
4. Home Economics
5. Humanities
6. Islamic Studies
7. Languages
8. Military Science
9. Nursing
10. Pre-Engineering
11. Pre-Medical
12. Technical

Most of the students opt for either the Humanities or the Pre-Engineering or the Pre-medical groups. The remaining nine groups are still not very popular among the students as shown by the enrolment in these groups which is very low in comparison to the other groups.

Amongst the three science groups in the list, that is the Pre-Medical, the Pre-Engineering and the General Science group, the first two are more popular than is the third. The aim of most of the students studying science at the Intermediate level is to seek admission in medical and engineering colleges, therefore the existing Pre- Medical and Pre-Engineering groups are essentially preparatory courses for medicine and engineering professions respectively. The Pre-Medical group is made up of the following subjects:- Biology, Chemistry, Physics. The Pre-Engineering group is made up of the following subjects namely: Mathematics, Chemistry and Physics while the General Science group includes the subjects like Biology, Chemistry, Geology, Economics, General Mathematics, Physics and Psychology. A student who opts for the General Science group will study any three of these subjects.

The students can opt for subjects from any of these three science groups provided they have studied science group subjects in component

2 of their secondary school curriculum scheme. Hence the study of these subjects at the Intermediate stage is meant to consolidate their knowledge in these subjects.

It is important to note that in this scheme of studies, Biology, which is included both in the General Science Group and in the Pre-medical science group, is taught as the subject Biology itself in only one Province of Pakistan. In the remaining three provinces, namely: the North West Frontier Province, Baluchistan and Sindh, it is taught as Botany and Zoology. For the last 15 years the Boards of Intermediate and Secondary Education in the Punjab have adopted as their textbook the American BSCS (Biological Science Curriculum Study) group text materials 'An Inquiry into Life' (Yellow Version).

It is important to note that at present the criteria of selection of candidates for both professional and general degree courses are the marks obtained in the Intermediate Examination.

Professional colleges admit only the top most students with A and A+ grades in the Intermediate examination. For general degree course the criteria is rather more relaxed, and students with B and C grades are also accepted in these courses, in addition to those with A grades.

1.24. Higher Education (Bachelor and Masters degree course)

After completing their Intermediate education students enter the fourth tier of education, namely Higher Education. Professional colleges and general degree colleges cater for degree courses. These colleges are either the responsibility of the respective Provincial

Governments or are affiliated with the Universities which are semi-autonomous bodies.

The duration of general degree courses both in the science and the arts subjects is two academic years. However, honours degree courses are of three years duration. The duration of professional degree courses varies depending upon the nature of the course (see Flow chart 1).

In all general Bachelor's degree courses students have to study a hard core of 3 compulsory subjects namely: English, Islamic studies and Pakistan Studies.

The medium of instruction in degree classes is mainly English but in many arts subjects lectures are delivered in Urdu.

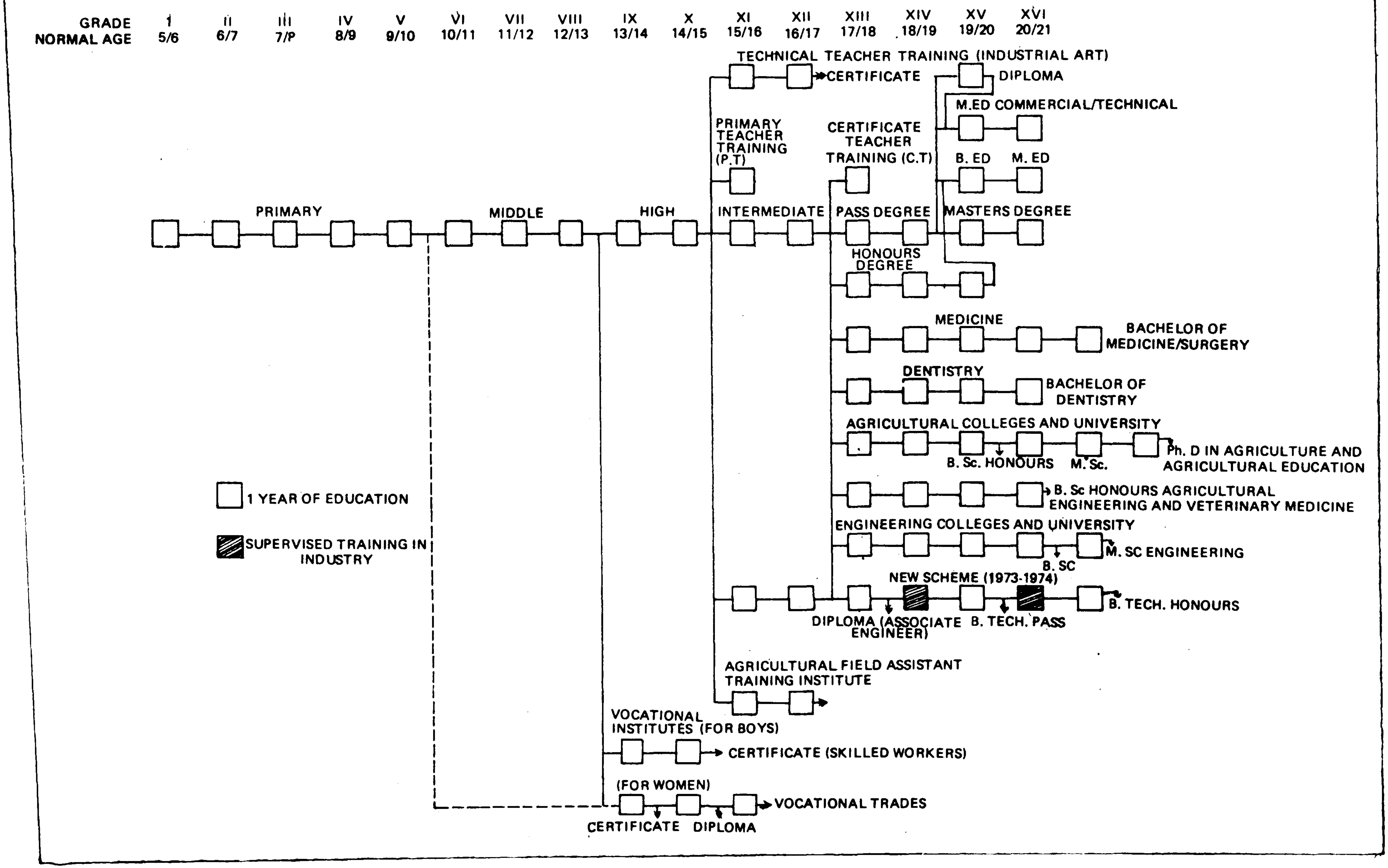
In science subjects practical work is an essential component of the curriculum and is included in the final assessment. In Bachelor's degree courses there is no research or project work to do, or dissertation to write. These are mainly taught courses with the syllabi and text books prescribed by the universities concerned.

Science subjects are mainly taught by lectures. Weekly practicals are carried-out according to the prescribed syllabus.

Promotion from one year of the course to the next depends on performance in examinations which are held by the college, but the final degree examination is a University examination and a Bachelor's Degree in Science (B.Sc.) or in Arts (B.A.) is awarded to the successful candidate.

Flow Chart Number 1

STRUCTURE OF THE EDUCATIONAL SYSTEM (FORMAL ONLY)



Master's degree courses are held in the Universities and in some Degree colleges. Entry to a Master's degree course requires a first division or a good second division pass in a Bachelor's degree in the subject appropriate together with good marks obtained in a special written test and an interview.

Master's degree courses are mainly taught courses. Science students carry out some independent research work or project and write a dissertation. Marks for project work and for the dissertation are included in the final assessment of their performance. Some universities have a semester system of examinations while others hold annual examinations, either at the end of each year or at the end of the whole M.Sc or M.A. course.

After completing a Master's degree the majority of the students join the teaching profession. The whole population of college and University lecturers is drawn from Universities. At present for teaching in a college to Intermediate and Degree students there is no requirement for having a professional qualification in pedagogy.

1.25. Teacher Education

A number of different institutes provide facilities for in-service and pre- service teacher training programmes for primary and secondary school teachers. Training for primary school teachers is offered in the schools called Normal schools. Teacher training colleges provide courses for secondary school teachers as do Institutes of Education and Research, though these cater for post-graduate Teacher Training courses.

Entry requirements for different teacher training courses vary. Some courses require one or more than one year of teaching experience, while others do not require any experience.

1.30. The organisation of the education system

The Federal and the Provincial government are jointly responsible for education. The Federal Ministry of Education has four wings namely: Curriculum, Planning, Administration and Culture. Each wing is in the charge of a joint Educational Advisor who is assisted by a number of Deputies responsible for different sectors of the wing. Four wings work in close collaboration with each other.

Responsibility for the administration and management of educational institutes is vested with the respective provincial governments.

At provincial level schools are operated through an administrative system at the Divisional and District levels. Institutions, which for secondary schools and above, are separately served are administered and inspected separately by inspectors and inspectoresses. The divisional inspectors are responsible for secondary education, the district inspector's responsibility is middle stage education and assistant inspectors are responsible for primary education. The education administration has been decentralised at provincial level by dividing the bigger regions into smaller units and most of the powers and responsibilities have been delegated to the district education officers.

1.40. The development of education in general and in science education in particular:- a review of development since 1947

Most of the countries which gained their political independence before or during 1960s placed much of their faith for improving living conditions on the expansion of education. This is evident from their educational policies and plans which set out ambitious plans for the expansion of their educational system (D'Aeth (1975)). Pakistan was no exception.

Jinnah, Pakistan's first Governor General, while addressing the first educational Conference held in 1947 emphasized that,

> "Under foreign rule for over a century, sufficient attention has not been paid to the education of our people and if we are to make a real, speedy and substantial progress we must earnestly tackle this question and bring our policy and programmes on the lines suited to the genius of the people, consonant with our history and culture and having regard to the modern conditions and vast development that have taken all over the world" (Government Report (1971), p.1).

Dissatisfaction with the education system for being unsuitable for predominantly agricultural societies, and also for ignoring their language, literature, religion and tradition and customs was an other common problem which the newly freed states faced (D'Aeth (1975)). At the time of its independence, Pakistan had an education system which was plagued with problems. Besides being felt to be unsuited to the needs of the country, the education system of Pakistan was facing the problems of lack of trained teachers, poor enrolment in schools, high drop-out rate, and a very high illiteracy rate.

The first eight years of independence (1947 - 1955) were mainly devoted to the problems of restoring the otherwise collapsing system of education and some achievements were made, as indicated in Table 1.3.

Table 1.3: Educational developments during the first eight years of independence.

Number of Institutes and enrolment	1948-1949	1953-1954
Primary Education (no. of schools)	38,122	41,651
Enrolment	3,643,000	4,962,000
Secondary Education (no. of schools)	6,275	5,551*
Enrolment	916,000	1,171,000
No. of colleges	90	132
No. of Universities	3	6

* The number decreases due to downgrading the weak schools to primary schools.

Source: The First Five-Year Plan, 1955-60 p.399

In 1955, eight years after independence, the first Five-Year plan of development was implemented. It covered the period (1955-60). It was not until the formulation of this First-Five Year Plan that educational development was viewed comprehensively in the framework of national development as a whole (Curle, A. (1966)).

It was pointed out in the first plan, in a review of achievements of the pre-planned period, that changes since independence were quantitative rather than qualitative, and that the main task of the first plan should be to achieve a better balance between quantity and quality in the educational system and to encourage the qualitative changes suggested by educational authorities (Government Report (1955)).

The plan was focussed mainly on training teachers at all levels, providing facilities for technical and vocational education, promoting teaching and research in science and technology, and improving existing schools. Primary education was given particular attention to lay the foundation for Universal education which it was hoped to be instituted by 1975. However, as Table 1.4 given below shows there was very little overall improvement in general. Perhaps the most serious failure of the First Plan was in teacher training. Although this was a matter of high priority, the output of primary school teachers did not increase at all (Curle (1966)).

Table 1.4: Educational development in First Five-Year Plan Period.

	1954-55	1959-60
Primary education		
Schools	41,500	44,200
Enrolment	4,266,000	4,706,000
Secondary education		
Schools	5,475	6,000
Enrolment	869,000	1,099,000
Teacher education		
Annual output, primary	7,400	7,400
Annual output, secondary	1,300	1,300
Technical education (including technical, engineering, medical, agricultural), annual output	1,121	1,767
College and universities enrolment	66,766	117,566

Source: Second Plan. p.339

Also during the first plan period there was no perceptible improvement in the quality of education though there was a major expansion of higher education, mainly in the colleges, whose number increased from 145 to 202 (Government Report (1971)).

In 1958 a National Commission on education was set up to carry-out an extensive and in depth study of all levels of education.

Although, as Curle (1966) has pointed out, this report of the Commission on National Education, which was published in 1960, covers almost every aspect of education in the country, its main concern was for the quality of education in science and technical and in vocational education. As is written in the report:

> "we have given special emphasis to the needs for scientists, engineers, and technicians because we believe that this has been our greatest weakness and the greatest failing of our education system."
> (Government Report (1960), p.12).

It deals with matters of education policy, the role of higher education, and the place of religious and moral instruction.

The Commission found the school curricula, particularly at the secondary school level, were too limited and mainly catered for an academic and literary education.

Science and mathematics and vocational subjects were either not included or were not compulsory. The commission recommended introducing vocational and technical subjects into the secondary school curriculum and including science and mathematics as compulsory hard core subjects, for secondary schools.

Teaching and learning methods were found to be heavily fact-oriented and assessment was limited to the test of memory to the extent of the exclusion of every other kind of learning. The commission recommended teaching methods ......

> "...which will excite the students intellectual interest and generate in him a spirit of inquiry and ability to apply knowledge to the situation of problems". (Government Report (1960), p.17).

Commenting on the state of teaching and learning methods used in laboratories, the commission's report said that the procedures used in college and university laboratories were perfunctory and lacking the educative value to justify the time and expense involved. Students either copied the 'right' answers from the fellow students or put down what they guess the expected out come to be (Ibid., p.41).

These kinds of laboratory exercises do not contribute to the intellectual development of the learner, they reported and should be replaced by a method in which students work from known to unknown. If our laboratories would not help develop intellectual skills and also integrity, honesty and objectivity they are a sheer waste of time and resources (Ibid., p.41).

Throughout its report the commission emphasised the need for an improvement in teaching and learning methods used in the theory lessons and in the practical work in science and a need to shift the emphasis from practices of cramming the facts and rote learning to a child centred learning to help develop habits of taking initiative, independent thought, perseverence, self reliance and application of knowledge.

In 1960 the Second Five-year Plan was implemented using the Commission's report as guide lines for future actions. The main features of the Second Plan were as follows; reorientation of school curricula towards science and science-based technical and vocational education, restoration and improvement of quality of education of all levels of education with adequate expansion of education with particular emphasis on the primary stage.

During the second Five-Year Plan period, i.e. 1960-65, science and mathematics were included in the compulsory hard-core subjects in secondary school curricula along with training programmes for the teachers of vocational and technical subjects. A review and revision of all other curricula at school level was initiated.

Most of the numerical targets of the Second Plan were achieved, for instance the number of primary schools increased from 20,909 to 32,589 and the number of secondary school increased from 2,970 to 4323. At the secondary stage the target enrolment was achieved with a corresponding increase in the number of teachers.

At the primary stage two million additional children to the original 189,000 were brought under instruction but there was no corresponding increase in the numbers of primary school teachers and it adversely effected the standard of education (Government Report (1965)).

The quantitative expansion in the number of schools and also in the enrolment in these schools exceeded the target of the plan, but there was hardly any qualitative change in the rapidly deteriorating educational standards (Government Report (1971)).

1.41. The third and the fourth Five-Year plan periods (1965-70 and 1970-75)

The third Five-Year plan (1965-70) was formulated with a new zeal and great hopes. The main thrust of the plan was to shift the direction of education from academic and literary subjects to science and science-based technological and vocational education.

> "To provide an educational system which would facilitate transition to an era of science and technology, promote political social and economic development and bring country's spiritual and cultural heritage into harmony with contemporary world.
>
> To raise the quality of education at all levels so that the youth may properly fulfil its nations' building tasks." (Government Report (1965), p.185).

In the programme of the third five-year plan science and mathematics were given special importance at all levels of education. To shift the emphasis from humanities and language teaching to science and mathematics, it was decided to restrict enrolment in humanities to increase enrolment in science and mathematics, particularly at the Intermediate stage. To achieve this aim the provision of trained teaching staff, physical facilites and improvement in curricula were considered important.

There were other areas of major concern of third Five-Year Plan Programmes such as for instance, widening the base of primary education and greatly increasing the facilities for technical and vocational subjects.

The programmes of the third Five-Year plan period, intended to achieve a shift in emphasis from academic and literary education to an era of science and technology, were only partially achieved. First the war with India in 1965 and then the floods within the country caused a diversion of effort and economy towards these problems of defence and safety.

Nevertheless, some progress could be seen to be made in the direction desired. The enrolment target at primary and secondary stage increased to 37 and 50 % respectively. At higher secondary school, an increase of 60% was achieved over the enrolment of 1965. The number of middle and high schools, increased to 800 and 1,400 respectively. Similarly the number of Intermediate and Degree colleges increased by 100 and by 80 respectively. In Intermediate and Secondary Schools the enrolment in science subjects increased by 100% (Government Report (1970)). However, the envisaged change in the balance in the enrolment in humanities and science subjects could not be achieved due to the increase in number of arts students in the colleges opened in the private sector. Similarly, there was no corresponding increase in the number of teachers, consequently the student-teacher ratio increased (Government Report (1971)).

At the end of the third five-year plan period the country was still struggling against an increasing rate of illiteracy, low enrolment in schools, constantly deteriorating standards of education and failure to bring diversification of the curriculum and the shifting of the trends towards science, mathematics and vocational education.

The Fourth five-year plan programme (1970-75) showed great concern for the achievement of the targets of shifting the trend towards science education and vocational and technical education, along with an improving emphasis on and restoring the quality of education in general. The country was still facing a shortage of skilled manpower for its industry, and teachers in science and vocational subjects for its schools. The bulk of skilled manpower and teachers was drawn from the higher secondary, i.e. Intermediate stage and secondary education institutes, so special attention was given to providing for these stages. Only one fifth of the students in secondary schools were offering science and vocational subjects in their examinations. Consequently there was still a shortage of science teachers in schools and also skilled manpower in industry. It limited the use of new techniques in industry.

The fourth five year plan period (1970-75) was a period of political unrest within the country; separation of the east wing took place during this period. The Plan's programmes were not implemented as envisaged, though the study of the plan shows that this plan envisaged bringing drastic changes in the education pattern to bring it in line with the socio-economic needs of the country. The major aims of the programme were to expand science education and science-based technical education, particularly at secondary level, since the bulk of labour force comes from this stage and its inadequacy to provide science education limits the flexibility and capacity to adapt to new techniques. A dire need to shift the emphasis from literacy and academic education to science education was felt to be imperative as was apparent from many of the plan's programmes.

The fourth plan was formulated within the framework of The Education Policy of 1972-80, which gave top priority to science and science-based technical and vocational education.

Table 1.5. Percentage distribution of enrolment in different Intermediate Degree and university level.

SUBJECTS	Intermediate		Degree		Post Graduate	
	M	F	M	F	M	F
Arts	47	76	51	78	44	62
Science	41	22	26	17	33	28
Commerce	12	-	21	1	3	-
Agriculture	-	-	2	-	13	-
Home Economics	-	-	-	4	-	3
Education	-	-	-	-	7	7

Source: Government Report 1976 p.24

The overall programme did not achieve all of its targets. Enrolment at University level increased greatly and primary education could not be expanded. Opening the new Universities further aggravated the problem and resulted in an inverted pyramid of education with a broad university education and a narrow base of primary education. (Government Report (1983)).

1.42. The sixth five-year plan (1983 - 88)

Ever since the inception of Pakistan the country has been struggling to combat illiteracy, achieve the target of universal compulsory education, shift the emphasis from an academic and literary type education to a more purposeful science-based vocational and technical education.

Progress has been made, but the major targets are yet to be achieved. The Sixth Five-Year Plan programme was formulated within the frame work of the National Education Policy 1979. Amongst the top most priorities of this programme are:

(i) to eradicate illiteracy using all existing resources, Although the plan could not be implemented fully, some progress was achieved in expanding the education system. New universities were opened, a University Grants commission, centers of excellence in marine biology, physics, analytical chemistry and in minerology were established during this plan period.

Most of the work on curriculum revision was either completed or was in its final stages of completion, by the end of the 4th plan period. This plan also could not achieve its targets for expansion of primary education, nor training of teachers for agro-technical and other vocational subjects. The educational standards were still deteriorating (Government Report (1970)) and the shift from arts to science and vocational education was yet to be achieved.

The fifth five-year Plan Period (1976-81) envisaged making up for the deficiencies of the previous programmes. Improvement in the standards of secondary and higher secondary education, and expansion of science education were once again amongst the major priorities of the plan.

In this plan the aim was to restrict the enrolment in arts subjects and to encourage enrolment in science subjects to create a balance in enrolment in two streams.

The enrolment in different subjects at Intermediate, Degree and post-graduate level shows an imbalance. Enrolment remained comparatively very high in arts subject compared to enrolment in science subjects, and in vocational and technical education (Table 1.5). Female participation in science and vocational subjects is even less than is male participation.

(ii) to make a massive shift towards science education at all levels of education and

(iii) expand the base of education by expanding primary education.

It has been decided to use all formal and informal education means to increase the incidence of literacy. For this purpose mosque schools, mass media and all other means of education besides formal education are being used.

Once again, in this sixth 5 year plan, the targets have been set to increase the enrolment in primary schools from the present 50 % of the population to 75 % by 1987-88. At present the primary education is still not compulsory.

The current plan envisages to making primary school education compulsory for all children and then to extend compulsory education to the secondary stage.

Science education and technical and vocational education have always been the top priorities of the various plans. But none of the programmes gave a disagregated programme for science education (Government Report (1984)).

Efforts have been made to change to an era of science education (Government Report (1970)) and curriculum reforms, teacher training initiatives and refresher courses, and provision of facilities were all steps in this direction. Even in the sixth plan there is still no disagregate programme for science education (Government Report (1984)) but formulation of The National Education Policy and augmentation of the sixth five-year plan programme with this plan and especially in conjunction with the Action Plan (1984) in which science education is dealt with specifically, there seems to be a chance that the shortcomings in science education can be overcome in a more systematic manner.

The main thrust of the sixth plan and the Action Plan of 1984, is a further attempt to bring science education in line with the needs of the country.

In the National Education Policy 1979, and in the sixth Five-year plan which is based on the National Policy, there are clear guide lines for improvement in science education. The emphasis is on teaching science as a process of inquiry to instil in students habits of scientific thinking, critical attitude, independent learning, scientific method of thought and inquiry skills. To achieve these aims the laboratory has been given a central role to play:

> "In order to promote the requisite competencies, skills and scientific attitude among the students practical components of the curricula would receive special emphasis. Text books and practical note books would be revised to bring out clearly the modern approaches in enhancing comprehension through laboratory experiments" (Government Report (1984)).

In the new programme, the teacher's role in curriculum implementation has been given a full cognition and there are plans to provide teachers' materials, there are plans to launch teacher training programmes and refresher courses to ensure the success of new proposals. Facilities of the laboratory and the library will be improved accordingly.

The current Plan 1983 - 88 shows a determination to eradicate illiteracy, to institute universal primary education and to bring about a reorientation of science education.

This review of the development of the education in the country reveals that, like any other developing country, Pakistan has accepted science and technology as the keys to the 'door' of economic and social success and provision of the best education in these subjects as the means to obtain the key.

From the first Education Conference held during the first year of independence and still today, all the major efforts are directed towards the expansion, improvement and popularisation of both science education and science based vocational and technical education in the country.

Reforms made in this direction started with the inclusion of science and mathematics in the schools' curriculum as compulsory subjects and with the introduction of diversified curricula in vocational and technical education both at school and college level. Provision of teaching staff and physical facilities accompanied these changes.

Throughout there has been a growing concern for provision of a science education which can provide the country not only with scientists, engineers, skilled and semi-skilled manpower but also enable citizens to live and act more thoughtfully and with greater understanding and assurance in this increasingly complex civilization (Kazi (1977)).

Several curriculum revisions have been carried out during the past two and half decades with the Secondary and the Intermediate stages the major areas of concern, since from these two stages students are channelled in different directions.

The emphasis has always been on a purposeful and goal-oriented science education to develop in pupils the common-sense scientific methods of thought, critical thinking, curiosity and the habits of independent learning.

To this end the curriculum reform movement of 1972 was the first major step. During this period new curricula were developed at all levels of education with secondary and higher secondary levels being the focus of attention. The thrust of curriculum reform movement was to introduce such teaching and learning methods into science education so as to develop the ability of students to arrive at important scientific knowledge, through self- conducted enquiry rather than transmission of knowledge through lectures and reading books (Kazi (1977)).

Science curricula were revised and new text materials were developed to achieve this goal. At the higher secondary stage the introduction of biology instead of botany and zoology as two separate disciplines, and the adoption of BSCS text materials 'An Inquiry Into Life' Yellow Version, 1968 edition, was an important change in this direction. The BSCS materials were adopted for two main reasons; (a) to introduce up-to-date knowledge of the subject (b) to shift the emphasis from cramming facts to inquiry and discovery- oriented teaching and learning (Personal discussion with two of the Curriculum Committee members (1985)).

The present National Education Policy 1979 and other related plans and programmes (e.g. the Action Plan (1984)) have clearly emphasised the need to teach science as inquiry method to instil inquiry skills and scientific attitudes.

Science education at the secondary and the higher secondary levels is the focus of attention in the new plan and policies. Particularly at the higher secondary level changes will be made in the text materials and teaching methods to orientate science education toward inquiry-based teaching and learning methods.

The curriculum reform movement since 1972 has been directed at these two tiers, with the same aims, i.e. to change the academic and literary type teaching and learning methods into inquiry-based methods so as to instil in students habits of critical thinking and skills of inquiry.

Adoption of BSCS materials 'An Inquiry Into Life' (Yellow version) 1968 edition, as the text for Intermediate biology classes was one of the major steps in this direction. These materials were adopted because, they were written as materials intended to develop inquiry skills, or at least it is claimed to be so by the authors of these materials. For the last ten to fifteen years these materials have been used as the text materials for the Intermediate biology course.

Viewing the present policy and plans, and the reasons for which BSCS materials were adopted, it seems timely to evaluate the effects of these materials on users perceptions, priorities and performances.

CHAPTER 2

LITERATURE REVIEW

2.10. Innovations in science education: A brief review of the history

The curriculum reform movement of the 1960s was started in order to fulfil the urgent need for more scientists, engineers and skilled manpower for the socio-economic and political security of America (Schwab (1960)). However, the shape which science education took and the direction of reform was largely determined by the nature of science as perceived by the educators and scientists at the time.

Until the 1960s science was perceived and taught as a body of immutable facts, so nearly independent of one another that new ones were added without sending the older ones into oblivion (Ibid.). In the 1950s this view was changing.

In America a major reform of the science curriculum began in the mid-1950s, for instance, the PSSC (Physical Science Study Committee) was funded in 1957. Shortly after the initiation of this curriculum development the Russians launched their Sputnik and this precipitated the release of large sums of money in the USA to fund many national ventures into the reform of science curricula (Baez (1976)).

Both educators and scientists in the USA joined together to carry out the curriculum movement and to steer it towards the aspirations and needs of the country. The science curricula were reviewed and were heavily criticized for portraying science "as nearly immutable rhetoric of conclusions in which the current and temporary construction of scientific knowledge are conveyed as empirical, critical and irrevocable truths" (Schwab (1960)).

Science as perceived now is a continuous process seeking more knowledge, new explanations and deeper understanding. New directions tend to generate new questions which call for further observations and more experimentation. Its knowledge is constantly being revised and expanded. But the curricula of the period before 1960s, and hence science education then, did not portray this spirit of science. This was what disturbed the curriculum reformers (Hurd (1971)). ‘The new programmes attempted to transmit this essence of science by directing the learning of students along the same paths used by scientists in accumulating knowledge so that the students will learn the basic structure of the discipline’ (Falk (1971)). Curriculum materials were devised and written in a deliberate attempt to achieve these aims.

The concept of the structure of each separate science subject was central to the reorientation of science education. Discussions of conceptual schemes, substantive and syntactic structure of science, learning hierarchies all reflected the desire to redefine the content and objectives of science teaching in terms more closely related to modern ideas of the structure of a discipline and to methods or processes of science by which a scientist was to acquire new knowledge (Shulman and Tamir (1973)). The issues concerning the structure of each separate science subject, and the form in which it should be transmitted to the learner, have been studied from both psychological and philosophical points of view.

Psychologists like Bruner, Gagne, Ausubel, and philosophers like Schwab, studied the issues from different perspectives and their theories and views formed the bases of many new curriculum innovations of the 1960s and even afterwards.

Probably Bruner's concept of teaching the structure of science which he presented in his book 'The Process of Education' (Bruner (1960)) was most influential in this regard, though the concept was interpreted and propagated in different ways by others who worked on these same lines.

Bruner's concept of teaching structure was based on a psychological point of view. He advocated the teaching of those very basic and fundamental concepts, principles and strategies which, if learnt well, can be transferred to other disciplines.

He claimed that these basic and fundamental principles are easy to retain in the memory longer, they make the subject more comprehensible and are the main road to adequate transfer of training (Bruner (1960)). Ausubel (1965) however, advocated the teaching of an 'organised body of knowledge as an explicit end in itself', while Gagne's concept of the structure of science (Gagne (1968)) is of an organised body of knowledge as well as intellectual skills or processes through which the knowledge is acquired. Gagne argues that it is the mode of acquiring knowledge that is the processes which should be given emphasis, particularly at secondary school level, and not organised subject-matter-content. According to Gagne, intellectual skills or processes rather than the organised subject matter could be presented in learning hierarchies, these were most effectively transferable and they were of most permanent worth to the learner. The content after all, he argued, can always be looked up in a reference book while the intellectual skills had to be re-established.

Gagne's concept of learning hierarchies and processes of science was highly influential. In particular, it is reflected in the AAAS's (American Association of Advancement of Science) programme, 'Science A Process Approach' (SAPA), a curriculum written for 5-13 year olds, and in many recent programmes which are being developed.

Bruner's original concept of the structure of science was explored and expanded by Schwab.

Schwab's concept of the structure of science, and its impact on both teaching and learning methods, is based more upon the philosophy of science than upon the psychology of learning, and as such is different from Gagne's and Bruner's perceptions and views.

This change of emphasis leads to a difference in the way the structure of science is perceived and hence explored and described, and so has implications on goals and objectives of teaching science.

Schwab (1962) studied and explored the structure of science and his conclusions and perceptions are based on his analysis of scientists' work.

Within a discipline Schwab distinguishes between the 'substantive' and the 'syntactic' structure of a discipline. The substantive structure of a discipline, as he has described it, is a body of concepts and commitments about the nature of a subject matter functioning as a guide to inquiry. The syntactical structure of a discipline, according to Schwab, is the pattern of its procedure (Schwab (1962)).

These two components of science, the 'substantive' and the 'syntactic' structure of science are also referred to in the literature as products and processes of science (for instance, Schwab (1960) Bruner (1960)). Science as Schwab has pointed out, was not merely the collection of facts. It was also the interpretation of facts, and the formulation of concepts. Concepts in science are used as the guiding principles for further study or inquiry and are themselves tested and revised. With each change in the conceptual system, the older knowledge gained through use of older principles sinks into limbo. The facts embodied are salvaged, reordered and reused, but the knowledge which formerly embodied these facts is replaced (Schwab (1962)).

It is this concept, based on a continuously accumulating and revisionary nature of science, which Schwab advocated should be transmitted through science education to the learner. His perceptions had a great impact on the curriculum developed by the Biological Science Curriculum Study group (BSCS).

One of the characteristics of a discipline is its conceptual structure. Each discipline also has its own particular modes of inquiry, special ways of gathering information and processing it into data. A science course should be concerned with both its conceptual structure and its patterns of inquiry (Hurd (1971)).

Curriculum reformers were essentially in agreement that the structure of science is composed of both process and product, but they differed as to what therefore should be taught, that is whether it should be process, or product, or both. The case for each was based upon a different rationale. The psychologists were more concerned with the problem of learning and transferability and retention of knowledge acquired while the philosophers seem to have analysed the issue from a purely philosophical point of view. The view that science should be taught as process and as inquiry emerged but the two different emphasises as to the nature of science inquiry were present right from the start.

2.20. The scientific inquiry as a way of teaching science

Most of the innovations of the 1960s had the notion of 'teaching science as inquiry' underlying the objectives of the courses. For instance, PSSC (Physical Science Study Committee), ESCP (Earth Science Curriculum Project), BSCS (Biological Science Curriculum Study) in America and Nuffield 'O' level and 'A' level courses in science subjects in Britain are amongst some of the courses of the 1960s which were based on the concept of teaching science as inquiry.

It is pertinent to explore the meanings which are attached to inquiry as used in the context of science education as a first step in embarking on a study of the inquiry method itself.

The term 'inquiry' when used in general terms in every day transactions, means the collection of information by asking questions (Young (1968)). But when used in connection with science education, a modifier 'scientific inquiry' is attached to it making it different from 'inquiry' as used in general terms. It is 'scientific inquiry' that was being offered as the paradigm on which to base science teaching.

The notions concerning the nature of scientific inquiry are both numerous and varied (Herron (1971)). The descriptions of inquiry as used in the context of science education also vary and are not essentially identical.

Seymour et al. describe inquiry as a 'set of activities directed towards an open number of related problems in which the student has as his principal focus a productive enterprise leading to increased understanding and application' (Seymour et al (1974)). Nagalaski (1980) describes inquiry as 'whatever a scientist does to solve a problem must be considered as inquiry', while Gagne' (1963) describes inquiry as 'the most critical activity scientists engage in'. He describes this activity as:

> "......a set of activities characterized by a problem-solving approach, in which each newly encountered phenomenon, becomes a challenge for thinking. Such thinking begins with a careful set of systematic observations, proceeds to design the measurements required, clearly distinguishes between what is observed and what is inferred, invents interpretations which are under ideal circumstances brilliant leaps, but always testable and draws reasonable conclusions".
> (Gagne (1963) p.145)

A number of attempts have been made to analyse the components of scientific inquiry. Curtis (1934) describes the following technique as characteristic of scientific inquiry:

(i) locating problems

(ii) making hypotheses from given facts

(iii) recognising errors and defects in condition or experiment described

(iv) evaluating data or procedures

(v) evaluating conclusions in light of the facts

(vi) planning and making new observations

(vii) investing check experiments

(viii) isolating experimental factors

(ix) using controls.

Kesler (1945) listed the following as components of scientific inquiry,

(i) sensing a problem

(ii) defining a problem

(iii) studying the situation for all facts and clues bearing upon the problem

(iv) making the best tentative hypothesis

(v) investing or planning one or more experiments to test the hypothesis

(vi) testing the hypothesis by carrying out experiments

(vii) running check experiments involving the results obtained in original experiments

(viii) drawing a conclusion

(ix) making inference based on conclusions when facing new situations in which the same factors are operating.

Atkin (1958) depicts inquiry as travelling through eight steps namely:

(i) sensing a problem and deciding to find an answer for it

(ii) defining the problem

(iii) studying the situation from all factors bearing on the problem

(iv) making the best tentative hypothesis as to the solution of the problem

(v) selecting the most likely hypothesis

(vi) testing the hypothesis

(vii) drawing a conclusion

(viii) making inference based on the conclusion.

Clearly all these attempts on analysing the components of inquiry have much in common. According to Dressel et al. (1960) the most common element listed in definitions of scientific inquiry include:

(i) recognition of the problem

(ii) collection of relevant data

(iii) formation of hypothesis

(iv) testing of hypothesis

(v) drawing conclusions.

Welch et al. (1981) describe inquiry as:

> ".....a general process by which human beings seek information or understanding. Broadly conceived, inquiry is a way of thought. Scientific inquiry, a subset of general inquiry, is concerned with the natural world and is guided by certain beliefs and assumptions".
> (Welch, Klopfer, Aikenhead, Robinson (1981) p.33)

They analysed inquiry into three main themes:-

(i) science process skills
(ii) the nature of scientific inquiry
(iii) general inquiry processes.

Within the category of science process skills they included a range of process skills, namely:-

(i) judging the appropriateness of an hypothesis treated to solve a personal problem on the basis of data obtained
(ii) interpreting data presented
(iii) observing and describing objects and phenomena
(iv) forming generalisations.

Within the general inquiry they included strategies such as,

(a) problem-solving use of evidence
(b) logical and analogical reasoning
(c) clarification of values
(d) decision making
(e) safeguards and customs of inquiry.

The third domain, as Welch et al. describe it, is essentially epistemological.

From the literature two integral parts of inquiry have emerged, one known as 'Process' the other as 'Product'. The former refers to the way inquiry is made, the methods of inquiry. The latter refers to the results of inquiry, what becomes known. The concern in science education is to involve pupils and students in both aspects and by this means overcome a major problem in teaching of science, which is that it had become too laden with facts and too involved with expository teaching. The inquiry- based curricula emphasize the process and the 'spirit' of science as much as content (Nagalski (1980)).

The descriptions of scientific inquiry given in the literature vary from writer to writer. However, in all descriptions, scientific inquiry is equated with the problem-solving activity which involves an array of processes. The processes listed in the literature under the heading of scientific inquiry have many factors in common but the lists vary from each other in the number of processes skills delineated. Even so these lists like the descriptions of inquiry, share the common factors of problem-solving processes.

SAPA (Science A Process Approach), for 5-13 year olds, also developed a list of science processes for the purpose of teaching science to 5-13 year olds. The stated objectives of SAPA were to enable children to acquire competence in the processes that scientists use in scientific inquiry. The complex processes which scientists use in scientific investigations were identified and broken down into a number of processes which are then arranged in a learning hierarchy. SAPA was the first to identify and order for the benefit of the learner the process skills according to their complexity and so the science processes which are incorporated into SAPA and later programmes in science education are considered next.

2.30. The process approach to teaching science

The process approach to teaching science is based on the rationale that there are recognised elements of commonness to scientific endeavour, basic skills and operations which are applied to the study of phenomena and which are not so delimiting as to interfere with a broad definition of science and the practice of it (AAAS (1963)).

Science process skills are advocated as the aim of teaching,

> ".....Essentially because process skills are life long learning skills. They are the tools which make any kind of learning in any subject area possible. There is an ancient proverb which says, 'Give me a fish and I eat for a day. Teach me to fish and I eat for a lifetime'. When we teach process skills to kids we are teaching them to fish and eat for a lifetime"
> (Mechling, Kenneth R. and Oliver, Donna. L. (1983) p.9)

More recently there seems to have been a very definite revival of interest in a process approach to teaching science. It has been advocated afresh both in America and in Britain, and in other countries. In Britain it forms an element in the recent policy for science education for 5 to 16 year olds (DES (1985a) paragraph 11) and is also to be assessed in the GCSE (DES (1985b)). However, SAPA was the first programme which used this approach - for teaching science to 5-13 year olds. SAPA was also the first programme in which science processes were identified, thirteen in all, and arranged into a learning hierarchy. These thirteen processes were divided into two groups namely, the basic processes and the integrated processes (see Table 2.1).

There is a progressive development within each process. At the earliest levels processes are discrete. They become increasingly interrelated as the progress in the course continues. For instance, the process of inferring is interrelated with the process of observing. The pupils develop competency in the basic processes and after they have acquired these skills, they go on to use these skills in the more complex integrated process of scientific activity.

Table 2.1. Basic and integrated processes as identified by SAPA (Source: AAAS, 1975)

Basic Processes

Observing	Measuring
Using Space/Time relationships	Communicating
Classifying	Predicting
Using Numbers	Inferring

Integrated Processes

Controlling variables

Interpreting Data

Defining Operationally

Formulating Hypotheses

Experimenting

Integrated processes are more complex skills and involve many basic processes. For instance, the process of experimenting involves the coordinated skills of all the basic and integrated processes. Hence, use of this skill requires facility with other process skills.

From the review of the literature it appears that SAPA set a tradition of compiling lists and inventories of science process skills. After SAPA's list many other lists and inventories of science process skills were reported in the literature. Some of these lists and inventories were developed to provide guide-lines for the teachers for planning instructions, some were compiled to develop performance tests, while some were developed for use both in planning instructions and assessments. However, most of the later lists reported in the literature are variants of SAPA's list of 13 science process skills.

For instance, Showalter et al. (1974) compiled a list of 15 process skills. Their list is essentially the same list as that of SAPA's except that they have added two more processes to the original list of 13 and have replaced the process experimenting with the process 'designing experiments'. The two processes added are 'formulating models' and 'asking questions' (see Table 2.2).

Table 2.2. List of the process skills compiled by Showalter et. al. The skills with stars (*) are integrated skills on SAPA's list (Showalter et al.1974))

The processes of science are:

1. CLASSIFYING. A systematic procedure used by a person to impose order on collections of objects or events.

2. COMMUNICATING. Any one of several procedures involving various media and which carries information from one person to another.

3.* CONTROLLING VARIABLES. Identifying and managing the factors that may influence a situation or event so that the effect of a given factor may be learnt.

4.* DEFINING OPERATIONALLY. Producing definitions of a thing or event in terms that give a physical description and/or that which results from conducting a given procedure.

5.* DESIGNING EXPERIMENTS. Planning a series of data gathering operations which provide a basis for testing a hypothesis or answering a question.

6. FORMULATING MODELS. Devising a mechanism scheme, or structure which will act or perform as if it were a specific real object or event.

7.* HYPOTHESISING. Stating a tentative generalization that may be used to explain a relatively large number of events but which is subject to immediate or eventual testing by one or more experiments.

8. INFERRING. Explaining an observation in terms of one's experience.

9.* INTERPRETING DATA. To find a pattern or other meaning inherent in a collection of data. Leads to stating a generalization.

10. MEASURING. A procedure by which one uses an instrument to estimate a quantitative value associated with some characteristic of an object or event.

11. OBSERVING. The most basic process of science in which a person uses his/her senses to obtain information about himself/herself or the world around him/her.

12.* PREDICTING. Predicting what future observations will be on the basis of previous information which distinguishes it from 'guessing'.

13.* QUESTIONING. To raise an uncertainty, doubt or unsettled issue which may be based on the perception of a discrepancy between what is observed and what is known by the questioner.

14. USING NUMBERS. The technique of using number systems to express ideas, observations, relationships, etc., often as a complement to the use of words.

15. USING SPACETIME RELATIONSHIPS. The description of spacial relationships and their change with time.

The list is given by the writers in alphabetical order with the intention of giving 'open-ended' status to each skill. No hierarchy is implied in order of the skills listed. 'The basic skills are viewed as being worthy of development even after a learner has made progress with one or more of the integrated processes' (Showalter et al. (1974)).

Nay and associates (1971) compiled an inventory of 14 processes in scientific inquiry. This inventory was compiled as a guide-line for teachers to plan their lessons for teaching science process skills. Once again no learning hierarchy is implied. The 14 major science process skills are grouped under four phases of investigation namely,

(i) Initiation
(ii) Collection of Data
(iii) Processing of Data
(iv) Conceptualization of Data.

The 14 major processes are distributed under these major phases though some major processes have sub-processes. (See Table 2.3).

Table 2.3. An inventory of processes in scientific inquiry Published by Nay and Associates in 1971

I. Initiation

1. Identifying and formulating a problem
   - (a) speculating about a phenomenon
   - (b) identifying variables
   - (c) noting and making assumptions
   - (d) delimiting the problem
2. Seeking relevant backing information
   - (a) recalling relevant knowledge and experiences
   - (b) doing literature research
   - (c) consulting people
3. Predicting
4. Hypothesising
5. Design for collection of data through field work and/or experimentation
   - (a) defining the independent and control variables in operational terms
   - (b) defining the procedure and sequencing steps
   - (c) identifying needed equipment, materials and techniques
   - (d) indicating safety precautions
   - (e) devising the method for recording data

II. Collection of Data

6. Procedure
   - (a) collecting, constructing, and setting up the apparatus or equipment
   - (b) doing field work and/or performing the experiment

(c) identifying the limitation of the design (as a result of failures, blind alleys, etc.) and modifying the procedure (often by trial-and-error)

(d) repeating the experiment (for reproducibility, to overcome limitations of initial design, etc.)

(e) recording data (describing, tabulating, diagramming, photographing, etc.)

7. Observing and observations

(a) obtaining qualitative data (using senses, etc.)

(b) obtaining semi-quantitative and quantitative data (measuring, reading scales, calibrating, counting objects or events, estimating, approximating, etc.)

(c) gathering specimens

(d) obtaining graphical data (charts, photographs, films, etc.)

(e) noting unexpected or accidental occurrences (serendipity)

(f) noting the precision and accuracy of data

(g) judging the reliability and validity of data

III. Processing of Data

8. Organizing the data

(a) ordering to identify regularities

(b) classifying

(c) comparing

9. Representing the data graphically

(a) drawing graphs, charts, maps, diagrams, etc.

(b) interpolating, extrapolating, etc.

10. Treating the data mathematically

(a) computing (calculating)

(b) using statistics

(c) determining the uncertainty in the results

IV. Conceptualization of Data

11. Interpreting the data

(a) suggesting an explanation for a set of data

(b) deriving an inference or generalization from a set of data

(c) assessing validity of initial assumptions, predictions, and hypotheses

12. Formulating operational definitions

(a) verbal

(b) mathematical

13. Expressing data in the form of a mathematical relationship

14. Incorporating the new discovery into the existing theory (developing a 'mental model')

V. Open-endedness

15. Seeking further evidence to

(a) increase the level of confidence in the the explanation or generalization

(b) test the range of applicability of the explanation or generalization

16. Identifying new problems for investigation because of

(a) the need to study the effect of a new variable

(b) anomalous or unexpected observations

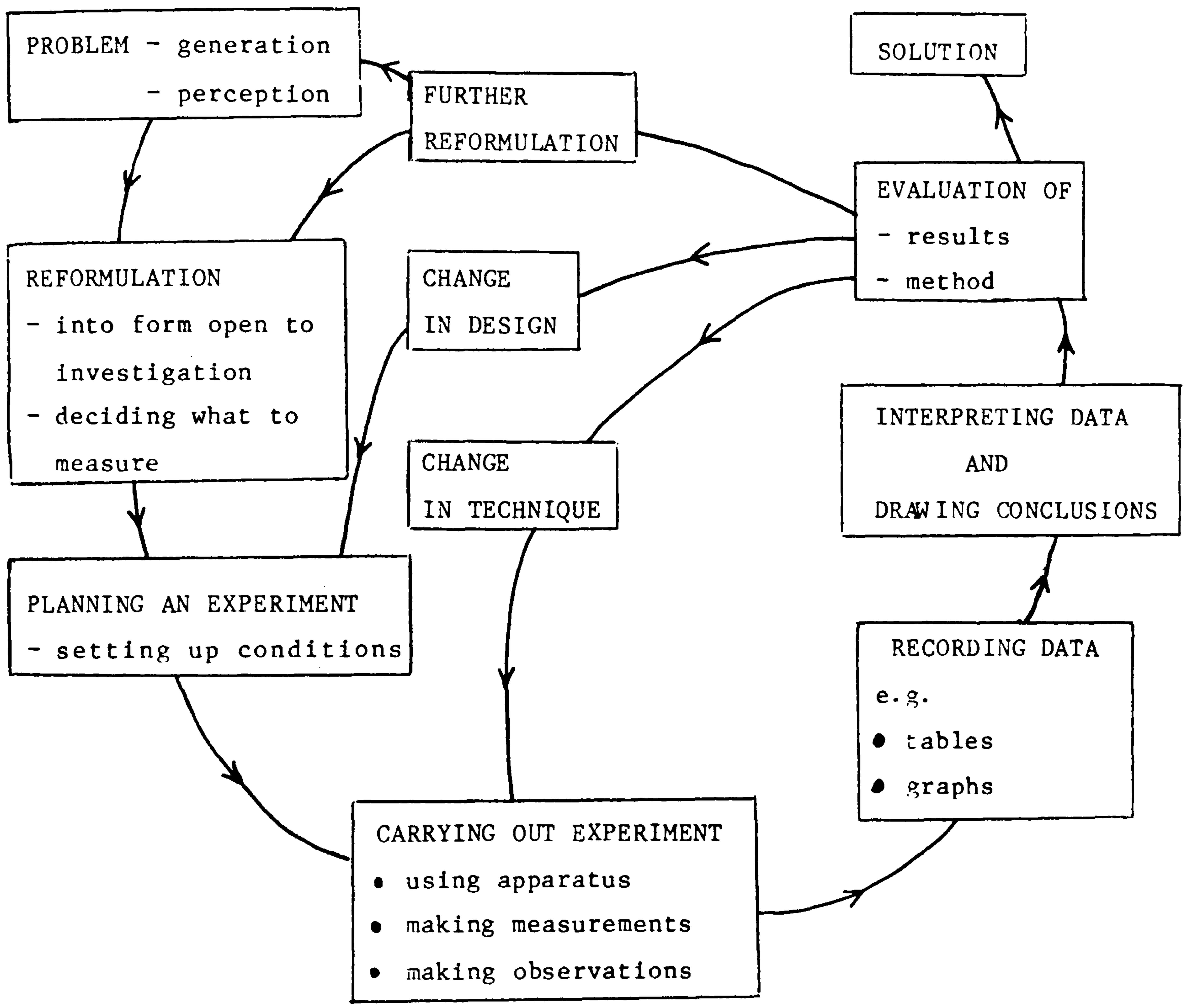
(c) incompleteness ('gaps') and inconsistencies in the theory

17. Applying the discovered knowledge.

In Britain APU (Assessment of Performance Unit, 19) has compiled a list of science process skills to monitor the performance of 11-15 year old children in science. The view of science education on which assessment is based perceives the aim of science education is being to enable pupils to apply scientific concepts and science process skills in problem solving. The framework for the assessment of the pupils' performance consists of categories and sub-categories which assess separately and in combination various parts of science processes (Harlen (1984)). The categories or the major processes and their sub-processes used in assessment are given in Table 2.4.

The sixth major category, 'category of investigation' given in Table 2.4 involves the use of all or most of the processes. For the assessment of this particular process, which is equivalent to the process 'experimenting' identified by SAPA, APU developed a model which they called 'the problem solving model', and used it as a check list of the pupils' performance (see Figure 2.1).

Figure 2.1: Problem Solving Chain (source: APU (1981))



Problem-solving model developed by APU portrays the dynamic nature of the problem solving activity which the lists and inventories prepared by SAPA and others do not show. The link of different categories (given in the Table 2.4) with the problem-solving model has been further elaborated in the Table 2.5. The problem-solving model and the link between science processes and problem-solving reveals that problem solving is seen as a cyclic activity involving a number of science processes.

Table 2.4. Framework of assessment of performance in science (source: Harlen (1984))

Category	Sub-categories
1. Symbolic representation	Reading information from graphs tables and charts.
2. Use of apparatus and measuring instruments	Using measuring instruments Estimating physical quantities. Following instructions for practical work
3. Observation	Making and interpreting observations
4. Interpeting and application	Interpreting presented information. Distinguishing degrees of inference. Applying science concepts to make sense of new information Generating alternative hypotheses
5. Design of investigation	Planning parts of investigations. Planning entire investigations. Identifying or processing testable statements
6. Performance of investigation	

Table 2.5. The link between the problem solving model and the category system. (Source:- Driver et al. report p. 86)

Category 5 Planning investigations	Problem - generation - perception Reformulation - into form open to investigation - deciding what to measure Planning an experiment - setting up conditions
Categories 2 & 3 Measurement and observation	Carrying out experiments
Category 1 Using symbolic representations	Recording
Category 4 Interpretation application	Interpretation

What the APU refers to as problem-solving is essentially what elsewhere is referred to as science by inquiry, for they both involve the same science process skills.

The recent policy statement by the DES in England and Wales (Science 5-16: A Statement of Policy (DES (1985a)) reflects that science process skills have been given a major importance in science education of the 1980's in Britain.

> "The essential characteristic of education in science is that it introduces pupils to the methods of science. So that scientific competency can be developed to the full, the course provided should therefore give pupils, at all stages appropriate opportunities to:
> make observations;
> select observations relevant to their investigations for further study;
> seek and identify patterns and relate these to patterns perceived earlier;
> suggest and evaluate explanations of the patterns;
> design and carry-out experiments including appropriate forms of measurement, to test suggested explanations for the patterns of observations;
> communicate (verbally, mathematically and graphically) and interpret written and other material;
> handle equipment safely and effectively;
> use their knowledge in conducting investigations;
> and bring their knowledge to bear in attempting to solve technological problems".
> (DES (1985))

The policy statement clearly delineates the science process skills which are considered as a major purpose of science education in Britain. In order to ensure that the curriculum provides opportunities to develop competency in science process skills, the DES (Department of Education and Science) in England and Wales has developed the national criteria for assessment in the GCSE (General Certificate of Secondary Education) examinations. The assessment objectives include an array of science process skills. For instance assessment objectives for biology and for science include a number of science process skills (See Tables 2.6 and 2.7).

Table 2.6. Assessment objectives for Biology
(Source: The National Criteria DES (1985b))

BIOLOGY - assessment objectives

Candidates should be able to:

1. make and record accurate observations;
2. plan and conduct simple experiments to test given hypotheses;
3. formulate hypotheses and design and conduct simple experiments to test them;
4. make constructive criticisms of the design of experiments;
5. analyse, interpret and draw inferences from a variety of forms of information including the results of experiments;
6. apply biological knowledge and understanding to the solution of problems, including those of a personal, social, economic and technological nature;
7. select and organise information relevant to particular ideas and communicate this information cogently in a variety of ways;
8. present biological information coherently.

Table 2.7. Assessment objectives for science subjects.
(Source: The National Criteria, DES (1985b))

SCIENCE - assessment objectives

Candidates are expected to demonstrate:

1. observe, measure and record accurately and systematically;
2. follow instructions accurately for the safe conduct of experiments;
3. communicate scientific observations, ideas and arguments logically, concisely and in various forms;
4. translate information from one form to another;
5. extract from available information data relevant to a particular context;
6. use experimental data, recognise patterns in such data, form hypotheses and deduce relationships;
7. draw conclusions from, and evaluate critically, experimental observations and other data;
8. recognise and explain variability and unreliability in experimental measurements;
9. devise and carry out experimental or other tests to check the validity of data, conclusions and generalisations;
10. devise and carry out experiments or other tests for particular purposes, selecting suitable apparatus and using it effectively and safely;
11. explain familiar facts, observations and phenomena in terms of scientific laws, theories and models;
12. suggest scientific explanations of unfamiliar facts, observations and phenomena;
13. apply scientific ideas and methods to solve qualitative and quantitative problems;
14. make decisions based on the examination of evidence and arguments;
15. recognise that the study and practice of science are subject to various limitations and uncertainties;
16. explain technological applications of science and evaluate associated social, economic and environmental implications.

All the approved GCSE syllabuses are required to comply with the assessment objectives set in the national criteria (DES (1985b)). Consequently, new science curricula are being developed with a deliberate intention of teaching science process skills. For instance, Suffolk Science and Warwick Process Science Projects are two of the recent programmes which are being developed with the major aim of teaching science process skills to the pupils.

Suffolk science is a modular programme for 14-16 year olds which emphasises skills and processes of science, content and sheer knowledge count less; real investigating counts more (Suffolk Science Project document (undated)). The skills and processes which will be taught in this programme are as follows:

1. Observing
2. Planning and designing
3. Investigating practically or by data search
4. Communicating
5. Collaborating effectively
6. Being concerned with application of science in society.

Each process listed subsumes a number of science skills. For instance the process Observing subsumes the skills of of measurement. All science processes delineated for the programme will be taught throughout the programme. No learning hierarchy is implied in the teaching of science processes. In this programme students performances will be assessed at three levels namely, Foundation, Merit and Special. Foundation is a minimum level of achievement expected of pupils who follow the course. At the second level of achievement called 'Merit' pupils are expected to show a significant achievement in mastery of skills, while at the special level a high degree of achievement is expected which will suggest that pupils are capable of more advance study.

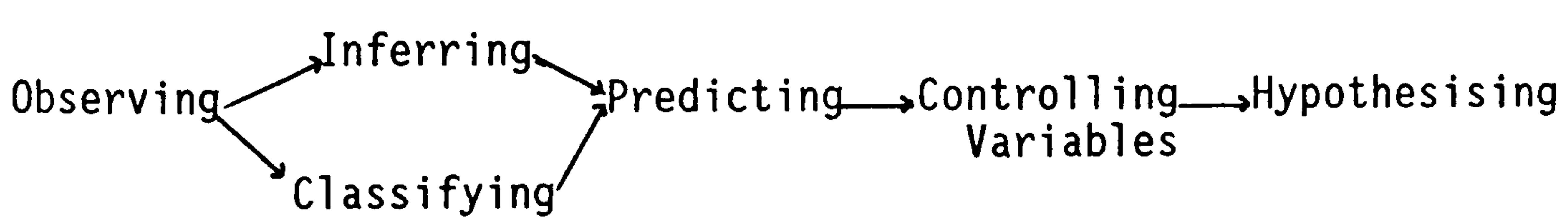
Assessment of the students' ability at three levels of increasing difficulty indicates the use of learning hierarchy approach suggested by Gagne (1963). Warwick Process Science Project (WPSP) is a new British programme for teaching science to 11-16 year olds. It was started in 1985. Some of its materials (for Years 1 and 2) are already published and available. Some will be published in 1988. These materials are written for the teachers to enable them to build their own courses. WSPS is a process-led programme with the major aim of teaching science process skills. The rationale of this programme as indicated in its introductory pack (Screen (1986)) is as follows:

> ".....it could be said that the most valuable elements of a scientific education are those that remain after the facts have been forgotten".
> (Screen, P. (1986) p.13)

Ten science processes and skills will be developed in this programme. These are as follows:

1. Observing
2. Inferring
3. Classifying
4. Predicting
5. Controlling variables
6. Hypothesising
7. Planning
8. Performing
9. Interpreting
10. Communicating.

The processes will be taught in a learning hierarchy starting from simple to more interrelated processes. During the first years of the course the processes will be taught directly. The learning hierarchy used in teaching of these skills is as follows:



In later work in the course the processes are grouped under the umbrella-type headings namely, Planning, Performing, Interpreting and Communicating. Each of these headings or processes comprises a variety of processes and skills.

Later in the course the pupils will be taught processes of science in problem solving and investigating activities. The problem solving activity is considered to be a cyclic activity involving a number of science processes and skills (Screen (1986)). The list of the processes and skills to be assessed in the activity of problem solving and investigation is given in Table 2.8.

Table 2.8. Science processes and skills comprised in problem solving and investigating (Source: Screen (1986))

1 -	Able to identify a variable.
2 -	Able to identify a number of variables.
3 -	Able to plan a fair test given the problem and all necessary apparatus.
4 -	Able to plan a fair test given the problem and a range of apparatus to choose from.
5 -	Able to suggest a testable hypothesis.
6 -	Able to suggest suitable apparatus.
7 -	Able to identify sources of error.
8 -	Able to suggest techniques for reducing error.
9 -	Able to assemble apparatus to form a system.
10 -	Able to modify equipment in an investigation in order to gain a wider range of data.
11 -	Able to carry out an investigation given a plan.
12 -	Able to plan and carry out an investigation which shows some attempt to solve a problem.
13 -	Able to plan and carry out an investigation which successfully solves a problem.

The factors included in problem solving and investigating in assessment in Warwick Science are more or less the same as APU has put into problem solving, and others have included in the scientific inquiry, and so once again the term problem solving that is in current use in science curricula and investigations encapsulates the science process skills identified by those who analysed the necessary components of science by inquiry.

Summary

A rapid growth in scientific knowledge altered the perception of the nature of science and the aims of science education. Science as perceived by the educators of the 1960s and those of today is a two component phenomenon. Now it is an established view that scientific discipline has two complementary components namely: products and process. There is also consensus of opinion among the educators that teaching of science as a mere collection of facts is impossible and of little worth to the learner and that it portrays an image of science which is not true to the nature of science. This new perception of science raises the question as to what is worth teaching, process or product or both. From the outset there is a difference of opinion among the educators on this issue.

One group of the educators advocated that science should be taught as process. Their view is based on psychology of learning. The second group analysed the problem from philosophic points of view and suggested that science should be taught as inquiry.

The proponents of teaching science as process had delineated the processes of science which scientists use in solving scientific problems to acquire new knowledge. They have developed lists and inventories of science processes and models of problem solving activity so as to provide guidelines to the teachers to plan their courses and lessons.

Advocates of the inquiry approach have analysed various aspects of scientific inquiry and have developed lists of inquiry skills required for conducting scientific inquiry, which is also considered as equivalent to problem-solving activity.

Although the two approaches, the process approach and the inquiry approach, are based on different rationale, it is established that scientific inquiry is something which proponents of a process approach referred to as problem-solving and it is the terminal objective of teaching science as process. So, a wide range of meanings are attached to the term 'process' of science. Sometimes, it is used to refer to discrete process skills of science, on other occasions it is meant to refer to the problem-solving activity as such, which is synonymous to the scientific inquiry since both involve the same processes. Hence scientific inquiry is an aspect of the process of science. It is the process of science which has been given importance in the mid-fifties and is undoubtedly a desired outcome of science education in both developed and developing countries today as witnessed by policy statements and curriculum projects in the second half of the 1980s.

2.40. Kinds of scientific inquiry

Scientific inquiry as described by Schwab (1960) has two aspects namely, 'stable inquiry' and 'fluid inquiry'. Stable inquiry results in filling the gaps in the existing knowledge - that is, it is cumulative - while 'fluid inquiry' results in a revision or replacement of existing principles. Stable inquiry is the one in which existing principles are used as facts and on the basis of these principles further inquiries are carried out, while in the case of the fluid inquiry the existing principles themselves are the subject of inquiry and research into these principles are carried out. It is the fluid inquiry which gives a revisionary character to science (Ibid.). This concept of two aspects of scientific inquiry is similar to Kuhn's concept of 'normal science and revolutionary science' (Kuhn (1962)) and Robinson's 'completive and generative inquiries' (Robinson (1965)).

Of the two aspects of inquiry, i.e. fluid and stable inquiry, it is the fluid inquiry which is advocated by science educators and by scientists for use in teaching science. They argue that in presenting science as stable inquiry only the cummulative aspect of science is revealed while its revisionary nature remains concealed and this conveys a distorted image of science.

Stable inquiry needs guiding principles and technology needs a body of knowledge of principles; with new advancements in technology new needs arise and as new problems are faced old principles and concepts wear out and so fluid inquirers and fluid inquiry are needed to search for new principles and revise or replace old principles. The increasing influence of technology in society, on socio-economic and political life requires the fluid inquirer and original scientists and engineers (Schwab (1962)). The need for scientists, engineers and skilled manpower, which initiated and structured the curriculum reform of the late 1950s still exists and has its impacts on the education policies of both the developed and the developing countries. Recent policy statements of the countries almost all over the world place a major emphasis on science-based technological education to fulfil the increasing demand for skilled manpower and for scientists and engineers. For instance, the policy statements of Britain (DES 1985a), Guyana (given in Brophy (1982)), Pakistan (Government Report (1979)), are a few to mention. In spite of the constant efforts to present science as a fluid inquiry in teaching and learning activities and in teaching and training materials, it has often been pointed out that 'in science education, though the emphasis is on fluid inquiry, the text materials and curricula more often than not present science as the stable inquiry.

However, the feasibility of the inquiry approach with secondary school pupils has never gone unquestionned. Many educators, for instance Gagne (1963) and Rutherford (1964) have argued that to conduct scientific inquiry one requires broad and incisive knowledge of general principles and facts and skills such as observation, measurement, inference. Secondary school children may not possess these skills or the knowledge to conduct fluid inquiry.

However, when Schwab (1960) refers to stable or fluid inquiry in science teaching he does not mean original inquiry by the students. His strategy suggests that the students will learn to carry out inquiry by inquiring into previous inquiries and not inquiry per. se.

Schwab has delineated four perspectives of viewing inquiry. The first perspective consists of major factors of inquiry, that is, the inquiry skills, which he takes to include both the basic and the integrated science skills. The second perspective is the major guiding principles of inquiry given in the form of conceptual schemes. The third perspective is to study critically the previously conducted inquiries by examining the guiding principles they used and the methods they employed in their investigations. The fourth perspective of inquiry according to Schwab (1971) is associated with the development of behaviours such as open mindedness, critical mindedness and curiosity.

This view of inquiry has its implications for the curriculum materials and methods. The text materials should be written in such a manner as to portray science, in terms of both the fluid and the stable inquiry. Teaching and learning activities should be planned in a manner to involve pupils in problem-solving activities. Briefly, science curricula should attend to both the process and product of science. However, in the 1950s movement many science educators have chosen to emphasize either the product of science or its inquiry process (Shulman and Tamir (1973)).

Recent developments in science education in both America and Britain seem to choose a middle way, that is, product and process of science are given equal importance so as to avoid the achievement of one at the expense of the other. Secondly, the question of feasibility of the scientific inquiry with secondary school pupils seems to be dealt with in new science programmes. For instance, in Britain there are programmes in science which start with training in discrete processes of science and progressively lead to problem-solving activities or, as it was more often called, inquiry. The focus of attention, still the same as was in the 1960's that is enabling pupils and students to solve problems so as to achieve the aim of providing opportunities for the general public to acquire scientific literacy and to provide a basic training for those who have the aptitude and potential for scientific research.

2.41. Scientific inquiry as used in the context of science education

The phrase, 'teaching science as inquiry' has been used in two ways in the literature. On one hand it is used to refer to the strategy of teaching and learning in which students learn science or acquire the knowledge of science by conducting inquiry. Schwab's phrase for this was 'teaching and learning as inquiry' (Schwab (1962)). Rutherford (1964) referred to it as 'inquiry as technique' while Shulman and Tamir (1973) describe it as 'the syntax of classroom and its consequences, the nature of transactions that will be conducted, the inquiry skills that will be mastered, the attitudenal metalessons that will be learnt'. On the other hand the use of the notion of teaching science as inquiry is meant to refer to the way science is presented in the text and it implies that the text will present both the products of science (i.e. knowledge) and the processes through which the knowledge is acquired. Schwab (1962) phrased this as 'science as inquiry', Rutherford (1964) named it as 'content as inquiry' while Shulman and Tamir (1973) elaborated it as the substantive focus of the classroom, what is taught and what is learnt.

From the review of the ideas of the proponents of inquiry as a method for teaching science it would seem that the curriculum materials should be presented to show that scientific knowledge is acquired by inquiry and that it is revisionary and cummulative in nature, and teaching and learning should take place by inquiry method.

"The phrase 'teaching science by inquiry method' is used to refer to two different strategies but in fact they are parts of the complete form of the idea of teaching science by inquiry method (Schwab (1962)).

The BSCS (Biological Science Curriculum Study) materials which are adopted in Pakistan as the text for Intermediate biology curriculum were developed on the basis of this concept of teaching science by inquiry method. Its major goals are to teach concepts of biology, inquiry skills and attitudes (Falk (1971)).

2.50. The impact of the innovations of the 1960s on science education and recent developments

The period between the early seventies to the mid-seventies was a period of disillusionment for many science educators (Holdzkom and Lutz (undated), Baez (1976)). There was a growing feeling that the efforts of the 1950s and 1960s have not been as successful as was hoped. Consequently, the direction of reform shifted from the production and development of materials to the evaluation of curricula of the sixties. The findings of the research shattered much of the confidence in the new curricula. In 1973 the American National Institute of Education came to the conclusion that, despite the efforts of the past decade, the schools were much the same as they had been. Generally the intentions of the new curricula are but rarely realised in the classroom to any significant degree. Eggleston et al. (1976) studied and compared the classroom practices of users and non-users of Nuffield science curricula. They concluded that there was considerable distance between the curriculum developers' views and the related practices within the classrooms. Other researchers contended that classroom practices reflected neither an emphasis upon inquiry and problem-solving nor a concern for technical and societal issues. These practices are not viewed as important by teachers and school administrations (Harms (1981), Yager et al.(1984)).

Observations of Stallings support this contention. Goodlad (1984) studied teacher's views and their classroom practices and he found that although the teachers consider the aims of teaching inquiry skills and scientific attitudes important they were not able to square their practice with their theory. Tobin (1986) in a study of the laboratory activities in secondary schools in Australia found that although teachers appeared to value laboratory activities, they did not implement them in the manner that facilitated the learning that was required. Research findings indicate that in day-to-day practice, teachers fail to consider the ultimate utility of the science knowledge and skills they teach. Preparing students for specific examinations appears to be the primary goal of most science teaching (Harms (1981), Stallings (1982)). The sixties experience in curriculum development and revision revealed that teachers are the key element in the implementation of a curriculum. Teachers make the most important decisions about course content and teaching methods which in turn determine the students' achievements.

Research findings have revealed that the innovations of the 1960s could not be implemented as was hoped. One of the reasons was teachers' inability to translate the philosophy of new courses into practice. Experience has shown that wherever the teachers were working according to the philosophy of the curricula, the gains in students' achievement were significant (Tamir (1979), Eggleston et al. (1976), Holdzkom (undated)). These findings have great impact on the curriculum development processes and the curricula themselves. Previously most of the science curricula were developed at national level both in America and in Britain. Though there was teacher involvement in curriculum development, it was only a small group of teachers representing the teachers. Recently, the new trends are to develop several local-level curricula (all in compliance with the National Education Policies and Criteria) to have maximum teacher involvement in curriculum development. Exemplary programmes in America are developed by teachers for their students and the teachers develop assessment techniques and tests. Similar trends are found in Britain. There is an increasing emphasis on teaching processes of science as is reflected in instructional objectives and assessment the criteria given in the policies and criteria. For assessment criteria there are explicit statements of criteria in knowledge, process and attitude domains. One example of such framework is the University of Oxford's Assessment framework development for assessment of science students. This assessment is process-based. It identifies four processes for assessment.

An assessment designed for a variety of courses (Source: OECA The Oxford Certificate of Educational Achievement undated)

Planning	Formulating problems Experimental design
Performing	Observing Measuring Data gathering
Interpreting	Data handling Drawing conclusions Predicting
Communicating	Reporting Receiving information

Similar schemes have been developed by teachers who have developed their own curriculum and assessment programmes, for instance, Suffolk Science, Warwick Science Project, developed in Britain and exemplary programmes in America. In these programmes criterion-referenced assessment is gradually replacing norm-referenced testing. students are once again given importance.

CHAPTER 3

METHODOLOGY

3.10. Curriculum evaluation: An overview of the models and strategies of evaluation

Curricula of the late 1950s and early 1960s were mostly developed by the project teams using RD and D (Research Development and Diffusion) model. This is,

> "....a process whereby ideas and tentative models of innovations are evaluated and systematically reshaped and packaged in a form that ensures benefit to users and which eases diffusion and adoption. In this process most of the adaptation and translation problems of the user are anticipated and adjusted for. The final outcome is therfore 'user-proof', guaranteed to work for the most fumbling and incompetent receiver" (Havelock (1971) p.314)

A great deal of optimism was found among the project teams about the success of innovatory programmes (Pinck and Martin (1978)). However, both the financing agencies and the consumers were interested to obtain evidence of the success of the new programmes (Lewy (1977) Skilbeck (1984)). Curriculum evaluation grew up as an element within the curriculum development movement as projects multiplied through the support of such agencies as Nuffield Foundation, the Schools' Council and, in other countries, national curriculum evaluation emerged as an independent field of study in the domain of educational sciences.

Prior to the 1960s three elements dominated evaluative approaches, the use of expert judgements, measurement, and Tylers' emphasis on objectives' testing (Maling-Keepes (1978) quoted in Davis (1980))

Tylers' concept of testing achievement of objectives had great impact on evaluation research in education. Taxonomies of cognitive and affective objectives were developed (for instance, taxonomy of educational objectives by Bloom et al. (1956)). A host of attitude scales and achievement tests emerged. The evaluation studies predominantly used the same research methods as used in natural sciences, that is, administration of pre-test and post-tests on experimental and control groups to assess the achievement of desired objectives. This classical paradigm of research has been variously labelled: 'scientific' or 'hypothetic-deductive', emphasising the testing of prior hypotheses, 'nomothetic' emphasizing the search for general laws, 'experimental', 'agricultural' or 'psychometric' indicating methodological links with approaches to research in the natural sciences, agriculture and psychology.

Use of achievement of objective model in evaluation of curriculum indicates that,

> "the assumption appears to have been that the move from the drawing board to the school or classroom was unproblematic, that the innovation would be implemented or used more or less as planned, and that the actual use would eventually correspond to planned or intended use. The whole area of implementation, what the innovation actually consists of in practice and why it develops as it does, was viewed as a "black box" where innovations entering one side somehow produce the consequences emanating from the other". (Fullan and Pomfret (1977) p.337)

Curriculum evaluation was synonymous with the student's achievement tests. Success and failure of an innovation was judged from students performances in the tests. The growing realisation of the 1960s innovations in those terms evoked a great concern to assess the full impact of the curriculum and this lead to the proliferation of evaluation models and strategies which gave new dimensions to curriculum evaluation.

The objective model of evaluation has been widely criticized for its too narrow approach. Cronbach (1963) was one of the first critics who questioned the completeness of the objective model of evaluation. He pointed to three types of decisions for which evaluation study could provide information namely, for making decisions about the individual pupils' progress, for judging the effectiveness of the programme and for making decisions to improve course materials. His perception of curriculum evaluation widened the role of curriculum evaluation and made it decision-oriented.

According to Cronbachs' definition evaluation is,

> "the collection and use of information to make decisions about an educational program" (Cronbach (1963) p.672)

Scriven's (1967) concept of summative and formative evaluation further delineated the role of evaluation.

Formative evaluation is carried-out during course development and provides information to improve course materials. Summative evaluation is conducted to assess the effectiveness of the finished product.

The distinction between the summative and formative evaluation is found useful in making decisions about the information which will be gathered, because certain interactions or events occur only during the development stages of curriculum and an evaluation carried out later may not have any reliable means of collecting information about these events.

However, a stark division of evaluation into these two separate categories is not advocated since such a differentiation may limit the information gathered. It is quite possible that an evaluation which is formative may also help a potential user to make decisions in adopting the programme, hence for some audiences it functions as formative evaluation and for others as summative evaluation. Similarly a summative evaluation may help teachers to review and revise their teaching methods (Cooper (1976)). Brophy's (1982) study of a distance teaching course for science teachers is an example, where the study was 'neither wholly summative nor wholly formative' (Brophy (1982) p.85).

Stufflebeam's (1967) contribution to evaluation models of the late 1960s was a step further. The model aspired to study the programme in an even broader perspective taking into account the context in which a programme is being used, the materials, the processes and finally the products. His model CIPP included four types of evaluation namely, context, input, process and product. This model aspired to a broad data base for decision making.

In 1973 Scriven introduced the concept of goal-free evaluation which could 'take much of the narrowness from the objective model but emphasis remains on product assessment' (Harlen (1976)).

Stake's (1977) model of curriculum evaluation was a step further from goal based scientific models of evaluation. Stake advocated a fuller countenance of educational evaluation. He suggested that evaluation should be oriented to the complex and dynamic nature of education, one which gives proper attention to the diverse purposes and judgements of the practitioner (Stake (1977)). His model of evaluation included three elements namely, antecedent conditions transactions and outcomes. Each of these had to be studied from curriculum developer's point of view, i.e. what were their intentions, as well as from users' observed behaviour. The purpose of study was to find congruencies among the three elements in intended curriculum and in actual practices and also to find congruencies between intentions and practices.

Stake's model was an improvement over the objective model which was accused of viewing the classroom as a 'black box' in which the new curriculum package was fed in at one end to emerge at the other relatively unscathed by its treatment at the hands of the teacher and the pupils' (Galton (1980)). Stake's model is equivalent to what Galton (1980) called a 'Glass box' model. In comparison with the objective model the model proposed by Stake provided a wider data base for decision making. Even so, his approach was still heavily measurement oriented (Taylor and Richards (1985)).

These and other models of evaluation, developed as an alternative to the objective model, widened the perspective of evaluation by drawing attention to the importance of curriculum processes and context in addition to the products, but they all made heavy use of psychometric measurement and were mainly concerned with collecting quantitative data for decision making.

During the late 1960s and early 1970s evaluation studies based on heavy use of psychometric's and quantitative data were criticized for treating education as scientific phenomena rather than as a human social enterprise (Taylor and Richards (1985)). Parlett and Hamilton criticized the experimental models of evaluation for they 'impose artificial and arbitrary restrictions on the scope of the study' (Parlett and Hamilton (1972)). There was an increasing emphasis on the application of research methods used in the disciplines of anthropology, economics and sociology in educational research (Hasting, (1969) Eisner (1985)).

These trends led to the endorsement of qualitative research methods variously referred to as ethnographic, case study or participant ——observation approaches and to the proliferation of qualitative evaluation models including Parlett and Hamilton's (1972) illuminative model, Stake's (1977) responsive model, Eisner's (1985) connoisseurship and criticism model and Guba's (1978) naturalistic model and MacDonald's (1976) holistic model.

A central goal of evaluation models based on techniques of anthropology and ethnography was "to get inside" the world of program participants and to understand, describe and explain the program and its effects from participants' points of views (Dorr-Bremme (1985)). Proponents of such models are more interested in the qualitative aspects of teacher-pupil-curriculum 'encounters' than with quantitative estimations of how far a curriculum has achieved its goals. The complexity and diversity of the socio-economic and political environment in which students and teachers work, which is referred to as the 'Learning milieu' by Parlett and Hamilton (1977), was the focus of attention in new evaluation models and,

> "the stance of the evaluators was to be that on anthropologists, concerned with description and interpretation rather than with measurement and prediction" (Taylor and Richards (1985) p.135).

The mission of proponents of such evaluation strategies was to facilitate democrative, pluralistic, process by enlightening all the participants (Cronbach et al. (1980))

Studies like the SAFARI project (Success and Failure and Recent Innovations) and UNCAL (Understand Computer Assisted Learning) (MacDonald et al. (1971)) and the evaluation of Humanities project (MacDonald et al. (1976)) in Britain, and Easley and Stakes' (1978) case study in science education are a few of the large scale studies which closely followed the holistic, illuminative or naturalistic inquiry approach.

The studies aimed to provide a description of learning processes and outcomes not in relation to prespecified criteria of success but in relation to how participants judge the educational worthwhileness of a curricular experience. However, there are many critics of these studies (for instance, Parsons (1976) Dorr-Bremme (1985)). Naturalistic, anthropological evaluation studies have been criticized for their lack of theoretical bases and the information gathered from such studies can be questioned for its validity and reliability since it cannot be rechecked and to a great extent depends on the evaluator's perception of the situation. Recent trends reveal a tendency towards a confluence of quantitative and qualitative approached to curriculum evaluation, for instance, Taylor and Richards (1985), Fraser (1980), Parsons (1981), and Williams (1981) advocate an eclectic approach to curriculum evaluation because,

> "....a wide ranging evaluation is a complex processes which is concerned with answering questions of many kinds. Some of these questions are such that empiricism cannot provide an appropriate basis for an answer. An evaluation for example, may include some discussion of nature and value of the aims of the development. Such discussion should be rational well-informed and conceptually coherent, but it is difficult to see anyway in which questions of this sort can be answered by empirical studies" (Williams, Norman (1981) p.71)

> "On the other hand there are other aspects of an evaluation which cannot conceivably be undertaken without reference to empirical data" (Ibid., p.72)

A more balanced view of curriculum evaluation would be to appreciate what strengths and weaknesses different models of evaluation possess, where they may be best applied, and how very limited remains our capacity to evaluate a curriculum in all its diversity and complexity (Taylor and Richards (1985)).

McCabe (1980) advocated a pluralistic approach to curriculum evaluation. In the pluralistic approach both quantitative and qualitative methods of research are used. Fraser and Smith (1980) used a similar approach for the evaluation of High School Education Law Project. Their experience suggested the desirability and potential usefulness of a confluence of qualitative and quantitative approaches in curriculum evaluation.

Brophy, in a recent study of a distance teaching programme for science teachers in Guyana, used a pluralistic approach to evaluate the programme. He found that, "No single method or technique provided an adequate or comprehensive evaluation and the results obtained from the different methods and techniques clearly demonstrate the need for using a pluralistic strategy in curriculum evaluation. Such a strategy should, however, maintain a balance between quantitative data and qualitative opinion". (Brophy (1982)p.255)

3.20. The evaluation strategy employed in the present study

Recent developments in the methodology of evaluation have admirably widened the domain of curriculum evaluation (Taylor and Richards (1985)). The following statement by Stake, though made almost two decades ago succinctly represents the recent trends in evaluation studies.

> "As evaluators we should make a record of all the following: what the authors or teacher or school board intends to do, what is provided in the way of environment, the transactions between teacher and learner, the student progress, the side effects, and last and most important the merit and shortcoming seen by persons from divergent viewpoints" (Stake (1969))

Lewy (1977) classified evaluation studies under three headings, representing three major approaches to evaluation:

(i) Achievement of desired outcome

(ii) Assessment of merit

(iii) Decision making.

Recently, there is an increasing emphasis on the decision-making role of evaluation.

The evaluation studies are carried out to collect information about the materials, transactions on processes, resources and students performance. In fact, decision-making evaluation encompasses the other two approaches mentioned.

In these approaches a number of criteria and data collection techniques can be used to study a particular issue. The criteria most often used and suggested (Lewy (1977), West (1975), Stufflebeam (1967) and Stake (1977)) include input (i.e. materials) processes (i.e. student-teacher-material interactions), and products (i.e. outcomes). It is advocated by Lewy (1977) and by Parlett and Hamilton (1972)) that a number of data-collection techniques be employed including questionnaires, observations (both formal and informal), interviews and check lists to obtain information from a variety of sources and methods.

In view of the purpose of the present study, and the perceptions of different writers and evaluators, the evaluation strategy suggested by West (1975) was judged to be the most appropriate strategy for this study. West used an eclectic approach in formulating his strategy of evaluation. This strategy is based on the assumption that an evaluation study should provide information to teachers, administrators and curriculum developers with evidence on which to base decisions to adopt or further develop the curriculum (West (1975) p.23). It is a tripartite evaluation strategy which incorporates:-

(1) An instrinsic evaluation
(2) A contextual evaluation
(3) A performance evaluation

The present study closely follows the strategy proposed by West with some modifications required by the nature of the present study.

Each component of the tripartite strategy is described here.

(1) The Intrinsic Evaluation

This is achieved through the study of published curriculum materials and is designed to identify and evaluate:

(a) the extent to which the intended outcomes are catered for in the materials
(b) the main curriculum assumptions of the author
(c) the proposed teaching and learning strategies
(d) the major resources and implications of the course.

In the present study both the officially prescribed practical guides for students, i.e. BSCS Students' Practical Guide and practical guides written by Pakistani writers (hereafter called Endemic Pakistan Books or EPB materials), were analysed.

(2) The Performance Evaluation

This assesses the achievement of the desired objectives. It is based essentially on a classical, or agricultural botany model of evaluation which requires a comparative study of performance of the pupils following the new and old curricula.

In the present study colleges were grouped into two types namely, the users of BSCS materials and the users of EPB materials. It is important to clarify at the outset that this is not a stark distinction.

Colleges in which lecturers' claimed to make maximum use of BSCS materials were classified as BSCS-users, while the colleges in which the majority of the teaching staff prefers and recommends EPB materials were grouped under EPB-users.

EPB materials are available on the market, students have easy access to them and there is no restriction on students using EPB materials. However, it is important to note that the colleges classified as EPB-users require their students to buy EPB materials, while colleges classified as BSCS-users do not recommend EPB materials at all and do not want students to use them in class.

Students' performance were compared in norm - referenced tests of their college examinations and in criterion - referenced situational tests developed for this study.

(3) The Context Evaluation

Context evaluation is designed to assess the effects of implementing the programme in terms of staff load, resource allocations and attitudes and practices of the users. The context evaluation, therefore, included the elements of the social anthropology model.

3.30. The sample

The data were collected from a number of sources, most of which involved Intermediate and Degree Colleges under the six Boards of Intermediate and Secondary Education in the Punjab namely:

(1) Bahawalpur Board

(2) Gujranwala Board

(3) Lahore Board

(4) Multan Board

(5) Rawalpindi Board

(6) Sargodah Board.

Full lists of the colleges which cater for Intermediate biology classes were obtained from the official records of each of the six Boards.

The colleges under each Board were then classified into one of the four major types namely:

(1) Intermediate colleges for boys

(2) Intermediate colleges for girls

(3) Degree colleges for boys

(4) Degree colleges for girls.

Then a random sample of ten per cent of each type of the colleges under each Board was taken using random sample means.

This was undertaken to obtain a ten per cent structured sample of the colleges. In fact a list of 33 colleges out of 224 colleges was obtained, this being 15 per cent of the colleges.

To each of these colleges two questionnaires were sent addressed to the head of the biology department. They were requested to hand over these questionnaires to two biology lecturers currently teaching biology to Intermediate classes.

In 1984 a field survey of a sample of the colleges under three boards of Intermediate and Secondary Education was carried out. These boards were Lahore Board, Multan Board and Rawalpindi Board.

This field survey was carried out on the one hand for collecting information from the lecturers of biology about their views, priorities and practices and their students performances in science-process skills. In this survey semistructured interviews were used to glean the information required. On the other hand, this survey was conducted to pilot students' questionnaires and criterion sampling assessment tasks.

The results of this survey revealed that the officially prescribed text materials were being used in only eight colleges; in rest of the colleges included in the survey the lecturers had prescribed to their students materials written by Pakistani writers. It was also found that the difference of the board had no significant effect on lecturers' priorities and practices.

In view of these findings it was decided to alter the sampling strategy for the final study. It was decided to ignore the difference of the boards and treat all the colleges under these three boards as one group. It was also decided to include all eight colleges identified as users of the officially prescribed text materials in the final study. Since the number of the colleges identified as users of the Pakistani materials was so big it was decided to take a ten per cent structured sample of these colleges. Later on the sample size was increased from ten to twenty per cent.

A list of twenty two colleges was obtained making up an approximately twenty per cent sample of the colleges. Of these 22 colleges, 16 colleges could be surveyed. These include five female Degree colleges, five male Degree colleges, three female Intermediate colleges and three male Intermediate colleges. Of the eight colleges identified as BSCS-users, six colleges could be surveyed. Of these, three were female Degree colleges, two were male Degree colleges and one was a male Intermediate college.

CHAPTER 4

THE INTRINSIC EVALUATION

4.10. Introduction

Intrinsic evaluation, which is concerned with the analysis of the curriculum, is considered an important element of a comprehensive summative evaluation. For instance, Eraut, Goad and Smith (1975), Lewy (1977), Scriven (1967), and West (1975) all advocate the inclusion of the intrinsic evaluation as a part of the summative evaluation.

Intrinsic evaluation is essentially concerned with the appraisal of curriculum materials. Curriculum materials have some value assumptions and pedagogic assumptions which are built into them and any study which completely ignores them risks perceiving them as non-problematic and insignificant. It provides the basis for studying the issues which might emerge from curriculum analysis and also augments the findings of both context evaluation andformance evaluation (Eraut et al. (1975)). Eraut et al. (1975) delineate three functions which an intrinsic evaluation can and may perform. These are:

(a) A descriptive-analytic function, directed at describing materials and elucidating their rationale.

(b) Evaluative function, which is aimed at analysis of the materials against a range of criteria irrespective of any specific context in which the materials are to be used.

(c) A decision making function which is context specific and advisory in terms of the selection or implementation of materials.

West (1975) suggests that all three functions are relevant to the purpose of summative evaluation. Various schemes are available for analysis of written curriculum materials, whether they are produced for teachers or for pupils and they include all written documents relevant to the curriculum in addition to the texts. (For instance schemes given in Eraut, Goad and Smith 1975)). Most of the schemes mainly serve a descriptive function and some, for instance, the scheme developed by Social Science Educational consortium (SSEC), are detailed and complicated. For the purpose of the present study the scheme developed by West (1975) was judged to be the most appropriate. It includes key aspects of descriptive, analytic and evaluative functions, but is based on the assumption that the evaluation includes both context and performance evaluation such that the intrinsic evaluation is only a part of the whole evaluation. The scheme includes the description of course materials, the analysis of antecedent conditions implied by course materials or course purposes, and the analysis of materials preferably either quantitative or both quantitative and qualitative. In the present study all these aspects are studied with the result that the intrinsic evaluation here serves both descriptive and analytic functions.

4.20. Description of the course materials

Official text materials prescribed for Intermediate Biology, included the adopted version of the BSCS text book, Yellow Version, 'An Inquiry Into Life' and also a practical guide for students. No teacher's materials or audio visual-aids or films are adopted.

Ara (1974) in an evaluation study of the BSCS text materials adopted in Pakistan found that the BSCS text materials have been adopted virtually without changing the original materials. However, a chapter on ecosystems written by a Pakistani writer has been added and the chapters on genetics and evolution have been omitted. The text book has topics under four major headings, namely, Unity, Diversity, Continuity and Interaction. Now altogether 26 chapters from the original BSCS materials are included in the course for Intermediate Biology students.

The biology laboratory manuals in use in Pakistan at the Intermediate stage are of two types. There is the officially prescribed Students' Laboratory Guide, 'An Inquiry Into Life' (Yellow Version 1968, edition). It is an American publication of the Biological Science Curriculum Study Group, Colorado, hereafter called BSCS materials.

The BSCS practical Guide for students contains 89 investigations of which 46 investigations have been included in the syllabus for Intermediate Biology. The Appendix 4.1 gives a list of experiments which are included in the syllabus. Then there are laboratory manuals which are written by Pakistani authors, hereafter called EPB materials i.e. Endemic Pakistan Books. EPB laboratory manuals are recommended by the biology lecturers and are widely used in the colleges.

There are a number of EPB laboratory manuals in use. Lecturers were asked to give the name(s) of the laboratory manual(s) they prescribe to their students, from the lecturers replies it was found that seven EPB laboratory manuals are currently popular among the lecturers. However, two of these seven manuals are more popular than the rest, as is apparent from the percentage of the lecturers recommending these manuals which is much higher than the percentage of the lecturers recommending other manuals. Some lecturers gave the names of more than one manual. See Table 4.1.

Table 4.1. The EPB Laboratory Manuals in use in the colleges. The manuals with asterisk are recommended by majority of the lecturers

Writers	percentage frequency
*Biology practical guide by Abdul Rauf Malik	37
*Biology practical guide by Sher Ahmed	28
Biology practical guide by Mukhtar Ahmed	10
Biology practical guide by Mushtaq	11
Biology practical guide by Dr. Feroz	5
Biology practical guide by Butt	7
Biology practical guide by Aziz	6

A comparison of the EPB materials written by different Pakistani writers showed that in these manuals the laboratory experiments, modes of representation and equipment and materials required for the experiments were essentially the same regardless of the author. In fact the researcher analysed materials written independently by two different authors and found them to be indistinguishable. For this reason just one of these EPB manuals has been analysed beside BSCS materials. The EPB manual analysed in the present study is the one which most of the lecturers recommend to their students.

4.30. Content analysis of the course materials: introduction

Textbooks are a most common form of curriculum materials throughout the world (Eraut et al. (1975)). A recent survey in America has shown that teachers' reliance on textbooks is very heavy and it seems that the secondary school curriculum and instruction are both determined almost entirely by the textbooks (Hurd, Bybee, Kahle and Yager (1980)). The importance of textbooks and other curriculum materials has always been recognised by educationalists and curriculum evaluators such that the analysis of these materials has been a feature of their intrinsic evaluation. Grobman (1970) strongly recommends systematic 'content analysis' as a major phase of formative evaluation. Anderson (1973) emphasised thorough descriptive information about the text materials as an essential requirement of all curriculum evaluation studies, and West (1975) and Eraut et al. (1975) in their models of curriculum evaluation recommends the analysis of textbooks as an important aspect of intrinsic evaluation.

Content analysis can be used to describe the characteristics of the curriculum materials with respect to, for instance, the compatibility of materials with specific aims, the nature of presentation and the value orientation of the materials (Grobman (1972)).

The tradition of acquiring experts' judgement on the materials has long been used by the evaluators. These judgements were mainly qualitative and sometimes descriptive of the materials. Recently many quantitative techniques have been developed and applied by the evaluators (for instance techniques developed by Romey (1968) Easley et al. (1964)). Easley's (1964) technique was specifically developed for the analysis of science materials and many researchers have adopted it (e.g. Brophy (1982), Herron (1971), Tamir and Lunetta (1978)) found it useful for their analysis of science materials. Some researchers (for instance Brophy (1982)) have augmented this technique with information gleaned by free response from students.

The text materials in use in Pakistan include both the officially prescribed BSCS materials and a variety of materials written by Pakistani writers referred to hereafter as EPB materials. Because the focus of attention in this present study concerns the processes of science, the materials which were analysed were those of the students' practical manual, both the EPB and the BSCS versions. However, lecturers' opinion about the text books have also been collected. In fact the lecturers' opinion about the text book revealed a great deal about their approach and priorities concerning their purpose of teaching of biology to Intermediate students.

4.31. Lecturers' comments on the text book

Both EPB-users and BSCS-users made extensive comments on the text materials in use. The comments that the lecturers made were classified into three broad areas namely:

(a) The links between the topics covered in the text book with the secondary school biology course on the one hand and with the B.Sc degree course in biology on the other.

(b) The general layout of the text materials.

(c) The approach of BSCS text materials.

(a) The links of Intermediate Biology course with the Secondary School Biology course and with the biology courses offered at B.Sc level

Both EPB-users and BSCS-users expressed the opinion that the present syllabus in biology, which in fact is composed of selected parts of the BSCS Yellow Version, has no link with the Secondary School biology course, nor, in their view, does it form a basis for further study of biology in degree classes. The lecturers said that both Secondary School biology and B.Sc. biology courses follow the old pattern of teaching biology which includes teaching morphology, taxonomy and anatomy and it is assumed that the students are conversant with basic terminology and facts. They say it creates problems at degree level and the lecturers of degree classes have to teach biology right from the scratch.

Most of the lecturers from EPB and BSCS-user colleges expressed this view. Only three out of 45 EPB-users and four out of 20 BSCS-users did not think that there is a lack of coordination in biology courses offered at these three stages.

The lecturers who expressed dissatisfaction with the present course of biology offered two suggestions for its improvement. One suggestion was to change Intermediate Biology course so as to establish a link between the courses. Almost all of the EPB-users were of this opinion (41/42) while 8 out of 16 BSCS-users who criticized biology education for non-coordination expressed this view. These lecturers suggested that at Intermediate stage more knowledge should be added and concepts of taxonomy, anatomy and morphology should be included to bring the course on par with B.Sc. course and Secondary School biology course.

The second suggestion given by the lecturers, mainly from BSCS-user colleges, was to change the B.Sc. course in biology and the Secondary School courses in biology in such a way as to establish a coordination between biology courses at these three stages of education. These lecturers do not think that the change other than updating the knowledge is needed in the Intermediate Biology course or textbooks.

(b) The general lay-out of the book

The reprinting of the BSCS books in Pakistan was said to be carelessly done and was criticized for the fact that the original text gave coloured illustrations and in the main text reference is often made to colours while in the Pakistani version these illustrations are in black and white. It was said to be a problem for students to follow the materials.

(c) The approach of BSCS text materials

The lecturers made comments on three aspects of the approach used in writing BSCS text materials namely, (i) weighting given to botany and zoology, (ii) inclusion of historical aspects in the texts and (iii) the language and examples used in the text.

The lecturers from both EPB-user and BSCS-user colleges criticized the BSCS text materials for their being heavily biased towards zoology. Lecturers who have their M.Sc. in Botany were particularly critical of this imbalance. It was also criticized that the content and the practical work are both heavily biased towards physiology to the exclusion of such topics as morphology, anatomy and taxonomy.

The lecturers made three major comments about the inclusion of historical aspects of biology in the text materials. A minority group mainly from BSCS-user colleges appreciated the inclusion of historical aspects in the text books. They said, ‘it creates interest in the subject and motivates the students to learn’. A majority of lecturers both from EPB-user and BSCS-user colleges criticized the inclusion of historical aspects in the text book. In their opinion it is confusing to the students and a hinderance in understanding the text. However, BSCS-users said that a suitable balance should be kept in the history and factual knowledge. Only two of the BSCS-user lecturers said that history should be completely deleted from the text and only factual knowledge should be given.

In EPB-user colleges the majority of the lecturers (29 out of 45) were of the opinion that history is useless and should be deleted. They claimed that in the maze of history, students lose the track and end up with superficial knowledge of the subject. However, a minority group (16 out of 45) appreciated the approach provided a balance is kept in the history and factual knowledge.

Ten EPB-user lecturers expressed the view that the present Biology textbook is good for general study but is a very poor textbook.

Table 4.2. Lecturers' views about the historical aspects of biology included in the textbook. Percentage given in brackets.

	EPB-Users n = 45	BSCS-Users n = 20
Historical aspects should be:		
(a) deleted	29 (64)	2 (10)
(b) curtailed	16 (36)	14 (70)
(c) retained	0	4 (20)

The comments and suggestions made by BSCS-users and EPB-users do not suggest that the two groups are very different from each other in their perceptions about the approach adopted in the BSCS material.

EPB-users expressed dissatisfaction with the relative coverage of the various branches of biology (anatomy, morphology, taxonomy) lecturers in BSCS-user colleges expressed similar views but to a much lesser degree. Neither group showed that they were conversant with the value of including in the text materials some historical perspectives. BSCS-users find the historical aspects interesting and EPB-users find it a problem in teaching biology which they have to resolve by giving notes, prescribing EPB materials which according to them give clear and to the point knowledge and do not leave the students to wander in the maze of history cum biology.

4.32. Lecturers' views about the BSCS Practical Guide

The lecturers both from EPB-users colleges and BSCS-user colleges were asked to give their opinion about the approach of the BSCS practical guide for students.

The results of the interview revealed that most of the lecturers from both EPB and BSCS-user colleges did not like the approach used in BSCS- practical guide. Their major criticism was on inclusion of the questions in the practical guide without giving the answers. Six out of 20 BSCS lecturers said that it would have been more useful if the answers were given alongside the questions. Twenty-six EPB-users expressed the same opinion. However, 16 EPB-users were totally against the idea of including the questions in the practical guide, 4 of these 16 saying that most of the questions given were trivial.

Fourteen BSCS lecturers appreciated the approach and said it was useful. Only three EPB-users fully agreed with the approach. However, the lecturers were asked to indicate in which way they found these questions useful. The lecturers replies indicate that the lecturers do not always associate these questions with science-process skills. Only seven BSCS- users and three EPB-users that these questions help the students to acquire training in observation or in making hypotheses.

Table 4.3. Lecturers' opinion about the questions given in the BSCS Practical Guide

Response	EPB–User (n = 45)	BSCS–User (n = 20)
Questions given in the practical guide;		
(a) could be useful if the answers were given	26 (58)	6 (30)
(b) are useful	3 (6)	14 (70)
(c) are useless	16 (36)	0

The lecturers indicated different purposes to the questions which are given in the practical guide. From the lecturers' replies two lists of purpose of the questions given in the practical guide are compiled (see Table 4.4).

Table 4.4. Range of lecturers' free response about the purpose of the questions incorporated into the students practical manual

Views of lecturers from BSCS-user colleges

- to give background information about the experiment
- to clarify some aspects of experiment
- to make students observe, describe, make hypotheses
- to motivate and involve the students in practical
- to make students understand the purpose of experiment
- to prepare the students for viva voce and examination
- to compare with the text
- to help students understand theory
- are trivial questions
- are ambiguous and confusing

Views of lecturers from EPB-user colleges

- to clarify different aspects of experiment
- to help remember facts, procedures and the results of experiments
- to understand the purpose of experiment
- to clarify basic facts and principles
- to check if the students have observed fully
- to check if the students have followed the procedure
- to motivate students to learn
- to develop a sense of inquiry
- to enable students to use alternative methods
- to make students research-minded
- to prepare students for viva voce
- too trivial

4.33. Experiments which are limited to dry-Lab sessions

According to the lecturers from BSCS-user colleges and EPB-user colleges all experiments included in the syllabus are not performed, some of these are limited to dry-lab sessions. In the EPB-user colleges about 30 per cent experiments (13 or 14 experiments out of 46 experiments) are such which are limited to dry-lab sessions. In contrast in BSCS-user colleges about 13 per cent experiments (5 or 6 out of 46) are such.

Three major reasons were given for not being able to perform these experiments namely, experiments are lengthy, experiments involve apparatus which is not available, and some experiments are not conducted because they are not expected in the examination. Lengthy experiments were said to be the major problem. Although in BSCS-user college lengthy experiments do not seem to be as big a constraint as in EPB-user colleges for in EPB-user colleges there are more experiments which are conducted as dry-lab sessions than in BSCS-user colleges.

4.40. The quantitative analysis of the laboratory manuals

A variety of techniques for analysing the curriculum materials have been developed and are reported in the research literature (many are reported in Eraut et al. (1975)). In the past, particularly before the boom of the 1960s curriculum reform movement, analysis of the materials was based on the judgement of specialists. But increasingly quantitive techniques have been developed. Techniques developed by Easley et al. (1967) and another by Romey (1968) are two of those which provide a quantitative analysis of the curriculum materials and they are often recommended.

The techniques of Romey (1968) and also of Easley et al. (1967) are particularly useful for the analysis of science materials and it is these which have been used by many researchers, for instance Tamir and Lunetta (1978), Herron (1971) and Brophy (1982). In the present study, the technique developed by Easley et al (1967) was judged to be the most appropriate technique on this occasion for the analysis of biology laboratory manuals in use in Pakistan.

In this technique the materials (which could be books, teacher's guides, student's laboratory manuals) under analysis are partitioned into assignable units, that is, one unit is assigned to only one category. Each unit is assigned to the category which best represents it. The assignable units can be of any length.

In the present sutdy units of different lengths were tried in order to establish what was the most suitable unit to designate for this exercise. At first each individual paragraph was taken and then parts of the experiments and finally the full experiment. The unit that proved to be the most suitable for the present study was found to be the full experiment itself. Each experiment therefore was taken as a unit.

In the BSCS Student's laboratory guide there are 89 experiments and hence 89 assignable units according to the strategy adopted in this study. Forty six of these experiments are relevant to the syllabus of Intermediate Biology in Pakistan and EPB materials have these 46 experiments. With few exceptions it was found that the units could be assigned with confidence to one or other of the categories. In just a few cases some parts of the experiment would suggest they should be allocated to one category and other parts of the same experiment to a different category but it was possible even in these few cases to decide which category most fully represented the unit as a whole as is required of the technique itself and the decision finally reached regarding the allocation of these few experiments.

4.41. The analysis of the laboratory manuals

The units (which is a whole experiment in this particular instance) of the EPB and the BSCS materials were classified in five different ways, each addressing itself to a matter of particular interest.

At first all 89 experiments given in the BSCS materials were analysed and a profile was drawn for these materials. Then the 46 experiments of BSCS materials which are in the syllabus of Intermediate classes were analysed using the same classification systems. The purpose of this exercise was to compare the profile of all experiments of the BSCS guide with the profile of the 46 experiments included in the syllabus. This comparison was carried-out to test for there being any evidence of the curriculum developers of Pakistan having made a particular selection of experiments from the BSCS Yellow Version in drawing up 46 experiments for the syllabus of Intermediate classes, rather than a random sample.

The EPB materials were also analysed using the same system as used for the analysis of BSCS 89 and BSCS 46 experiments. The purpose of analysing EPB materials was to identify the differences, if any, between the BSCS version of these experiments and EPB version of the same.

The five systems of classification used and the results of the analyses are described below and on the following pages taking in turn each classification system applied in turn to three groups of materials namely; BSCS 89 units, BSCS 46 units of the syllabus, and EPB 46 units.

4.41.1 The classification systems used and the results of the analyses

At first a classification system was used which would serve to show to what extent the experiments are presented in a way consistent with the inquiry or process approach. This is claimed to be a feature of BSCS materials (Hurd (1971)) and is also a requirement of the Intermediate Biology teaching according to Policy statements (Government Report (1979)).

To this end the units were classified under one of two headings namely, either as a unit presented in a way predominantly concerned with process or as a unit presented in a way predominantly concerned with teaching content.

A unit was put under the process heading if it was judged to be catering mainly for the science process skills for instance of making observations, measurements, classification, inference and hypotheses.

A unit was classified under the category of content based aim if it was judged to be catering mainly for teaching standard techniques, giving factual information.

Accordingly all three groups of materials, the full complement of the BSCS 89 experiments, the BSCS 46 experiments specified in the Intermediate Biology and the 46 experiments in the EPB materials were classified.

In order to develop a reliable system of classification of experiments into the categories they best represent, the students' practical guides were analysed several times at different time intervals. The experiments were classified and a week later the task was repeated. After a further one month the units were again classified and all 3 results compared in order to determine the reliability of the analysis. The results are given in the Table 4.5. The results of the third analysis were used in the study itself.

Table 4.5 : Results of the analyses of the students' practical guides The number given under each category represent the number of units/experiments.

Practical Guides	Attempt number	Aims: Process-based	Aims: Content-based	Inquiry Levels 0	Inquiry Levels 1	Inquiry Levels 2	Inquiry Levels 3	Integration with the text 0	Integration with the text 1	Integration with the text 2	Integration with the text 3	Availability of materials yes	Availability of materials no	Time required 1P	Time required >1P
BSCS '89'	1	63	26	24	61	4	0	0	29	34	36	80	9	58	31
BSCS '89'	2	70	19	15	72	2	0	0	25	37	27	78	11	59	30
BSCS '89'	3	69	20	12	76	1	0	0	25	37	27	78	11	58	31
BSCS '46'	1	30	16	14	32	2	0	0	16	17	13	38	8	32	14
BSCS '46'	2	34	12	10	36	0	0	0	15	18	13	35	11	33	13
BSCS '46'	3	35	11	7	39	0	0	0	15	18	13	35	11	33	13
EPB '46'	1	1	46	45	1	0	0	0	16	17	13	38	8	32	14
EPB '46'	2	5	41	44	2	0	0	0	15	18	13	35	11	33	13
EPB '46'	3	5	41	44	2	0	0	0	15	18	13	35	11	33	13

4.41.2 The results

The results revealed that the full set of the BSCS materials are predominantly process-oriented and they cater for the teaching of one or more process skills. Analysis of the BSCS materials chosen for inclusion in the Intermediate syllabus do not show any signs that the materials are particularly biased towards either content or process-based aims. The ratio of process-oriented and content oriented materials is approximately the same as in the full set of 89 BSCS experiments. There is a fair number of experiments in the syllabus catering for science process skills.

Table 4.6. Number and percentage of units classified as Process or Content units Percentages given in brackets.

	Category	Number of units classified under each category in the BSCS 89	BSCS 46	EPB 46
Content	Units mainly catering for teaching factual knowledge	20 (22)	11 (24)	41 (89)
Process	Units mainly catering for teaching process skills	69 (78)	35 (76)	5 (11)
Total		89 (100)	46 (100)	46 (100)

A comparison of the 46 BSCS experiments (in the syllabus) with the same experiments but written by Pakistani writers revealed that in the Pakistani version of the same 46 experiments the presentation is heavily content-oriented to the extent of exclusion of process skills. A ratio of 41 content-based experiments to five process-based experiments shows that EPB materials are mainly catering for content teaching, whether it is teaching of techniques or facts and principles. The EPB materials provide the student with full information leaving, very little for them to think and solve.

4.41.3. The classification of the materials according to the level of inquiry

Since the present study is especially concerned to learn of the process approach, all units were subjected to a second classification intended to establish the level of inquiry adopted by the curriculum writers in presenting their materials.

The criteria used were developed on the one hand by Schwab (1962) and further developed by Herron (1971). This has given rise to four categories of levels of inquiry and are given in Table 4.7.

Table 4.7. Levels of inquiry in the presentation of materials

Level	Description
	Problem - Method - Results
Zero level	Given - Given - Given
Level One	Given - Given - Open
Level Two	Given - Open - Open
Level Three	Open - Open - Open

According to Herron, a text (experiment or theory) is at zero level of inquiry if the materials provide the problem, the method and the results either explicitly or implicitly. In the initial trials of analysing EPB and BSCS materials in which Herron's description of zero level was used, it was found that this description was not appropriate for the present purposes, since EPB materials virtually always give the answer to each and every problem. Whereas in BSCS materials, though cues and leading questions are given, only rarely is a clear answer given as well. The application of Herron's description of zero level rendered this category less discriminating in the present instance and so it was decided to use a rather relaxed description of zero level, taking into account only those occasions where the answers were given explicitly since in this way this category proved itself more informative and discriminating .

4.41.4. The Level of inquiry in the presentation of BSCS and EPB materials

The results of the analysis of the three groups of materials are given in Table 4.8.

Table 4.8. Level of inquiry in the presentation of materials. Percentage is given in brackets.

Level of Inquiry	Description			Material		
	Problem	Method	Results	BSCS(89)	BSCS(46)	EPB(46)
0	Given	Given	Given	12 (13)	7 (15)	44 (96)
1	Given	Given	Open	76 (85)	39 (85)	2 (4)
2	Given	Open	Open	1 (2)	0 (0)	0 (0)
3	Open	Open	Open	0 (0)	0 (0)	0 (0)

The results reveal that more than 80 per cent of the BSCS '89' version experiments are at the level one of inquiry, while about 13 per cent are at the zero level and there is only one unit which reached level 2.

However there are a number of inquiries in which new problems are identified in the manual and the students are invited to design their own experiments (level 2) but mostly these are optional.

A comparison of the inquiry level profile of the 89 experiments of the BSCS materials with the 46 experiments of BSCS included in the Intermediate Biology syllabus reveals that the profile of the two is similar, it indicates that the curriculum developers in Pakistan had not introduced a bias when choosing the materials at least with respect to them being more or less inquiry oriented.

A comparison of the BSCS 89 and BSCS 46 version with the EPB materials shows that there is a marked difference in presentation of the experiment. Ninety-six per cent of the experiments in the EPB materials are at the zero level of inquiry, leaving only two at level 1 and none at all at levels 2 and above.

EPB materials are written in such a way as to remove the opportunity for inquiry from them. They cater for an expository method of teaching and learning. The fact that the original BSCS materials have been recast in this fashion suggests a preference for these materials, and a preference for an expository method of approach to teaching and learning. In comparison to EPB materials, even though BSCS materials seldom go beyond just the level 1 of inquiry, these materials definitely provide more opportunity for the learners to use process skills.

The BSCS materials, as is revealed in this analysis, are highly structured and designed in a manner that gives a student a particular form of exposure to science processes, one which is a highly guided training in process skills. This training is virtually missing from the EPB materials, not from the selection of BSCS experiments that have been included in the Intermediate Biology syllabus, but by the way they have been re-presented in the EPB materials, these having been written by writers in Pakistan and adopted by the majority of colleges in which Intermediate Biology is being taught.

4.41.5. Profile of the practical work for its integration with the theory work

A third classification system was adopted in order to find out the extent to which the practical work was integrated with the theory work in the textbook. The need for this classfication arose from the fact that many lecturers maintained that there was no integration between theory work and the practical work. This was the most commonly expressed problem for justifying why lecturers claimed that the practical work in the biology syllabus was worthless.

On this occasion four levels of integration were created, based upon those used by Tamir and Lunetta (1978). These are given in Table 4.9.

Table 4.9. Description of different levels of integration of experiments with theory lessons

Zero level	If the topic under investigation has not been covered in the text in the theory book
First level	If the topic under investigation has only been referred to in the theory book
Second level	If the topic under investigation is directly discussed in the theory lesson before carrying out the investigation
Third level	If the topic under investigation is to be performed before reading the relevant theory hence forming a basis for the topics covered in the theory

This classification system was applied only to the BSCS materials, since the experiments given in the EPB material have been shown previously to be essentially the same as those given in the BSCS materials. It is just the style of presentation that is different.

The results obtained show that the full list of 89 laboratory investigations of BSCS materials are integrated with the text given in the theory book, though at different levels of integration.

Table 4.10 Level of integration of experiments with the theory work. Percentages in brackets.

Level of Integration	Number of experiments	
	BSCS '89'	BSCS '46'
0	0 (0)	0 (0)
1	25 (28)	15 (32)
2	37 (42)	18 (39)
3	27 (30)	13 (28)

The majority of the investigations are to be performed after reading the theoretical background, but about 30 per cent are to be performed before reading the relevant facts in the theory book. These are to be used as starting points for the study of new topics. The choice of the 46 BSCS experiments for inclusion in the syllabus was criticized by the lecturers for being inappropriate. According to their comments no care has been taken to include the experiments which are relevant to the theory work. The present analysis shows such a criticism is not substantiated, all the 46 experiments in the syllabus are integrated with the theory work and the selection of 46 experiments out of 89 given in the BSCS materials has by no means resulted in non-integration of the theory work and practical work.

By integration the lecturers mean that the topic under investigation should be thoroughly covered in the textbook, for instance, if the students dissect a frogs they should have read all the systems and structures of frog in their textbook.

4.41.6. Time required to complete the experiments

The experiments included in the syllabus were heavily criticised by the lecturers for being too lengthy to perform. Due to shortage of equipment and facilities these experiments could not be performed, they claimed, and are limited to dry-lab. Once again the full 89 experiments in the BSCS texts were classified, this time according to the amount of time required to complete an experiment.

The amount of time required was determined by carefully reading the experiments and the 'teacher's guide' for the BSCS Yellow Version practical work, for the amount of time required for completion of an experiment is given in the teacher's guide. It is important to note that here the time required for an experiment is calculated only on the basis of the time needed for students to set up the apparatus and collect their data. The time required for the preparation of materials is not included since that is done by the lecturer or by the laboratory assistants.

For this analysis each experiment (i.e. each unit) was classified into one of two groups namely, either (a) the experiments which take only one laboratory period (90 minutes) to complete or (b) the experiments which take more than one laboratory period (90 minutes). The results obtained show that 59 experiments out of the 89 are such that can be completed in one laboratory period, while 30 experiments are such that take more than one laboratory period. In comparison, out of the 46 units included in the syllabus, 33 experiments are such that they could be completed in one laboratory period while 13 experiments take more than one laboratory period for completion.

Table 4.11. Time required for the completion of experiments
Percentage given in brackets

Time required	BSCS '89'	BSCS '46'
One laboratory period	59 (66)	33 (72)
More than one laboratory period	30 (34)	13 (28)

These results indicate that 30 per cent of the experiments could not be performed due to limitations of time. The lecturers frustration seems to be justified to some degree. If about 30 per cent experiments have to be limited to dry-lab it would seem to be wise to review them.

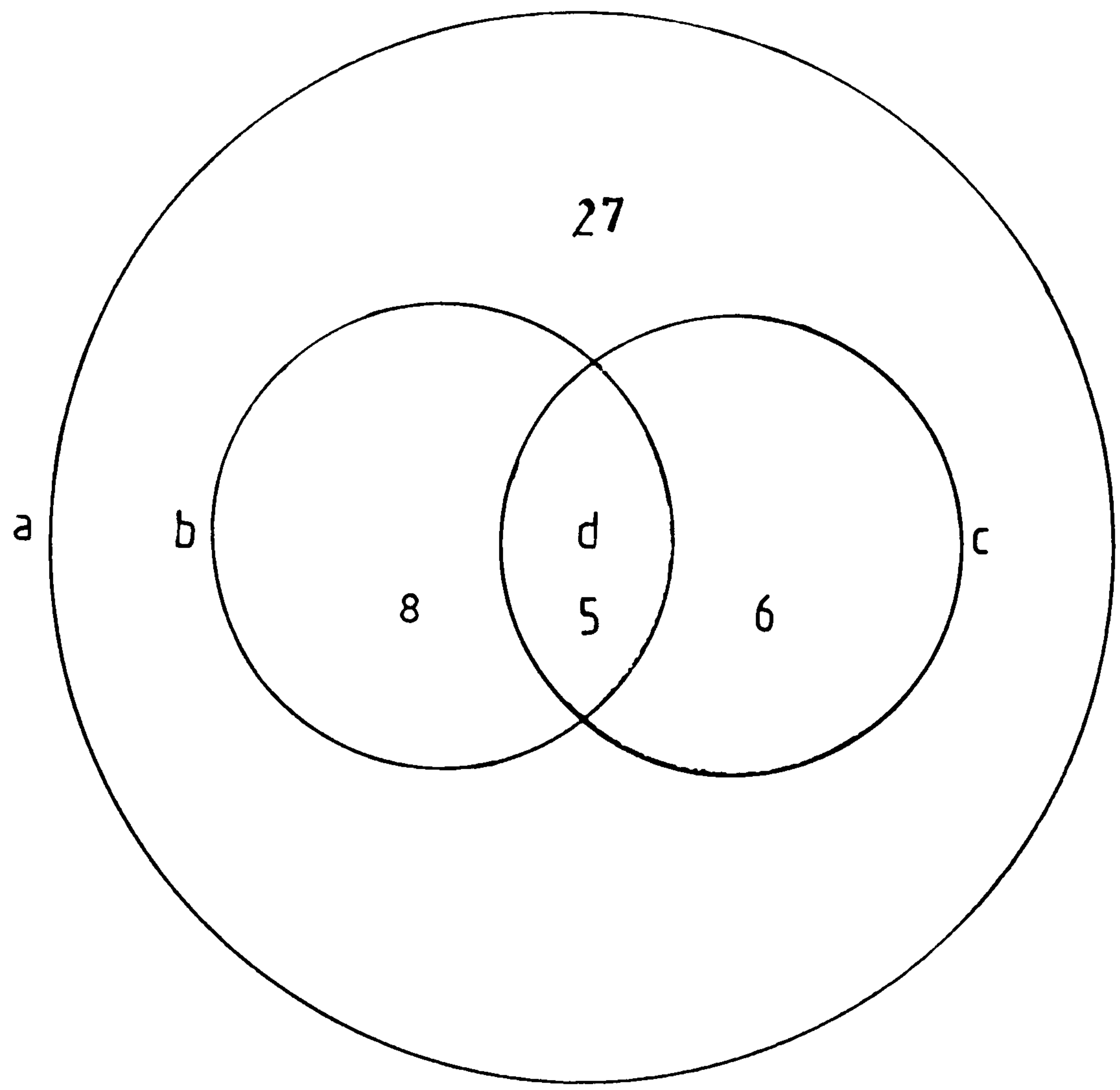
4.41.7. Profile of the experiments according to the materials

The fifth and final criteria used for the analysis of the units was the materials required for the experiments. One of the criticisms of BSCS experiments made by the lecturers was that the flora and fauna studied in the BSCS materials are American and there is a need to include Pakistani flora and fauna. The second objection about the materials used in the experiments was that they require equipment which is not available in the colleges.

The present study of the experiments has revealed that none of the experiments involve plants and animals specific to America only. As for the objection about the sophisticated equipment is concerned, 11 out of 46 experiments are such which involve materials or equipment which is not available in many colleges. This could be a limiting factor in performance of these experiments.

<u>Summary</u>:- On the whole the analysis of the materials revealed that BSCS materials cater for process skills and are not heavily content-oriented, while EPB materials are heavily content-based and do not cater for process skills. The mode of presentation of EPB materials is expository and more like a traditional cookbook style of laboratory manual than a process-based or inquiry-oriented manual. The materials are found to be integrated with the theory work and at various levels of integration, so there is no apparent justification of the lecturers' criticism on the non-integration of theory work with the practical work.

So far as availability of time and materials are concerned, there is a problem since there are 5 experiments (out of 46) for which neither the materials are available nor the time. Eight experiments require more than one laboratory period but for these experiments materials are available. However, there are 27 (out of 46) experiments are such which can be performed. (See Venn diagram, p.122). The lecturers strong preference for EPB materials is taken to mean that their approach towards the practical work is traditional and expository since the only difference between the BSCS and the EPB materials is one of the approach.



a = Forty six experiments
b = Experiments which require more than one lab. period
c = Experiments for which materials are not available
d = Experiments for which both the materials and time are not available

4.50. The teaching and learning modes

Biology is one of the seven compulsory subjects which an Intermediate pre- medical group student and a General Science group student has to study. It is composed of a practical and a theory component.

Every week students attend six theory periods each of 45 minutes duration (one period per day) and two practical periods each of 90 minutes duration per week (i.e. twice a week). There are no tutorials, project work or field studies in the curriculum of Biology. It is interesting to note that in EPB-user colleges which have more than one lecturer for teaching biology, botany and zoology topics are distributed among the lecturers. Those lecturers who have an M.Sc. in botany teach botany topics while those who have an M.Sc. in zoology teach zoology topics. In BSCS- user colleges one lecturer teaches the whole course. In colleges with a large number of students, each class is divided into two, and sometimes more, practical groups depending on the number of students. One group works in the laboratory at any one time in EPB-user colleges while in BSCS- user colleges at any one time two groups work in one laboratory each under the supervision of a lecturer.

4.60. The assessment and examination methods

At the Intermediate stage a public examination is held at the end of the second year. Beside this public examination colleges also give their own examinations at the end of each term. During the first year of Intermediate students take three college examinations. Two of them are held at the end of each term. These examinations are to assess students progress during each term. The third examination again set by the colleges is held at the end of the first academic year. It is a promotion examination and students are promoted to second year on the basis of their performance in this examination.

In the college examinations held during the first year, in most of the EPB- user colleges there is no practical component, while in BSCS user colleges students' performance in practical components is assessed.

In the second year of the Intermediate Biology course most of the EPB-user and all the BSCS-user colleges include a practical component in examination. But, as the lecturers from EPB user colleges said, these practical examinations are not taken seriously.

In the public examination, both theory and practical component are included, the practical examination carrying twenty five per cent of the total marks allocated to Biology. Students are required to pass in both theory and practical examination.

4.70. Antecedent conditions

4.71. Entry qualifications of biology students

As an entry requirement for Intermediate Pre-medical group, candidates must have passed their Secondary School Certificate Examination with passes in Biology, Chemistry, English, Islamic studies, Pakistan studies, Physics, Urdu, If a candidate has a London or a Cambridge University General Certificate of Education he/she must have studied the same subjects for GCE examinations.

The sample of students in the present study was taken from both BSCS-user colleges and EPB-user colleges. Seventy-six students from BSCS-user colleges and 203 students from EPB-user colleges filled in the questionnaire. The students were required to provide information about the subjects they studied for their Secondary School Certificate Examination in GCE London/Cambridge University and the marks they obtained in these subjects.

Some of the students did not remember the marks in individual subjects, others were not very sure of their memory so each student's marks were checked and or entered from the college record by the researcher. Six students from BSCS-user colleges had GCE passes and the college did not have records of their detailed grades. Another two students records were not available, nor did they remember their detailed marks in GSCE (Secondary School Certificate Examination).

In one of the EPB-user colleges the principal did not want to spare the clerk to fetch the record file for the researcher to check the marks. In this particular college the students did not give their detailed marks and the Principal did not allow the researcher to record it from the college record. So in about seven per cent of all cases (14 out of 203) the detailed marks of the students were not available.

In all other colleges the researcher was readily allowed to record these details from the college record files. In the present sample from both types of the college i.e. EPB-users and BSCS-user colleges none of the students in EPB-user colleges had GCE from London or Cambridge University, whereas in B-uSCS user colleges about seven per cent of students (of the sample) had GCE certificates. This is reflected in the lecturers comments that in BSCS-user colleges most of the students come from better shcools or have better education. The detailed marks of the two groups of students i.e. BSCS-users and EPB-users are given in Appendix 4.2 and Appendix 4.3.

The chi-square test was computed to test for a significant difference in the grades of students in EPB user colleges and those in BSCS user colleges. The result shows that for English there was no significant difference between the two groups of students. However, in all science subjects including Mathematics, more students from BSCS user colleges had significantly higher marks than the students in the EPB-user colleges. The difference is significant at five-percent level.

4.72. Type of the schools EPB-user and BSCS-user students have studied in their Secondary School Education

At the secondary stage different types of institutions offered courses in Secondary School Education. Some of these schools are

English medium, like convent schools and some public schools and privately owned schools, while most of the government schools are Urdu-medium schools. The students from EPB-user colleges (n=203) and BSCS-user colleges (n=76) were asked to indicate the type of school they have attended. The data are summarised in the Table 4.12.

Table 4.12. Type of school students in EPB and in BSCS-user colleges have attended. Percentages are given in the brackets.

School	BSCS-users (n = 76)	EPB-users (n = 203)
Government schools	38 (50)	149 (74)
Convent schools	9 (12)	5 (2)
Private schools	26 (34)	27 (13)
Public schools	3 (4)	12 (5)
Private candidate	0 (0)	10 (5)
Total	76 (100)	203 (100)

About half of the students in BSCS-user colleges had studied in Government schools, while about three quarters of students in EPB-user colleges had studied in Government schools. Only about one quarter of students in EPB-user colleges had studied in schools other than Government schools.

4.73. Medium of instruction in schools

In BSCS-user colleges half of the students had Urdu as a medium of instruction in their schools, the other half had English as a medium of instruction in their secondary school. In EPB-user colleges more than three quarters of the students had Urdu as a medium of instruction in their schools. Only about one quarter had English as a medium of instruction in their schools.

Table 4.13. Medium of instruction in schools. Percentages are given in the brackets

Medium of Instruction	EPB–Users (n = 203)	BSCS–Users (n = 76)
Urdu	162 (79)	40 (52)
English	41 (21)	36 (48)
Total	203 (100)	76 (100)

4.74. Practical work in Biology at Secondary School stage

Students were asked to indicate whether or not they had done any practical work in biology in their Secondary Schools. The results are summarised in the Table 4.14.

Table 4.14. Practical work in Biology at Secondary School. Percentages are given in the brackets.

Response	EPB-users (n = 203)	BSCS-users (n = 76)
Yes	137 (67)	42 (55)
No	66 (33)	34 (45)
Total	203 (100)	76 (100)

4.75. Use of BSCS Practical Guide 'An Inquiry Into Life' by the students

BSCS students' practical guide has been prescribed for the students as the official practical text. To ensure that students can buy the prescribed guide, a cheap paper back edition of the American text has been published in Pakistan.

In the present study the students were asked if they had a personal copy of the official text. The results are summarised in the Table 4.15.

Table 4.15 Number of students who have their own copy of BSCS Practical guide. Percentage given in the brackets

Response	EPB-users (n = 203)	BSCS-users (n = 76)
Yes	142 (70)	73 (96)
No	61 (30)	3 (4)
Total	203 (100)	76 (100)

The results reveal that the number of students who have their own practical guide is significantly higher in BSCS-user colleges than in EPB-user colleges ($P<0.001$).

Students were further asked to indicate how often they use the officially prescribed practical guide. The results are summarised in Table 4.16.

Table 4.16. Frequency of use of Practical Guide. Percentage given in the brackets

Response	EPB-Users (n = 203)	BSCS-Users (n = 76)
Never	62 (31)	5 (7)
Rarely	25 (12)	5 (7)
Often	51 (25)	12 (16)
Frequently	42 (21)	23 (30)
Always	23 (11)	31 (40)
Total	203 (100)	76 (100)

The results from two types of the colleges were tested for significance of difference in use of the official practical guide. Chi-square test was computed which gave a value of 25.319 and, with four degrees of freedom is statistically significant. More students in BSCS-user colleges own a copy of the BSCS practical guide but also those who possess a copy use it more often in BSCS colleges than do those in EPB-user colleges.

CHAPTER 5

THE CONTEXT EVALUATION

5.10. Introduction

The 1960s experience of curriculum innovation shattered most of the confidence in teacher proof materials. The assumption that "treatment" is parcelled up in the materials and is not appreciably effected by the teacher, the pupil, or the other aspects of the learning environment (Harlen (1976)) was contradicted by the research findings. Soon after the curriculum reform movement of the 1960s it was realised that the impact of innovation is not a set of discrete effects but an organically related pattern of acts and consequences. To understand fully a single act one must locate it functionally within the pattern (MacDonald (1976)).

Recognition of the importance of the learning environment in success or failure of the innovations is apparent in the latter strategies of evaluation presented by opponents of the classical model of evaluation. For instance, in the ‘Illumination model’ of evaluation proposed by Parlett and Hamilton (1972) prime importance is given to the ’learning milieu’, which they describe as the social-psychological and material environment in which teacher and student work together. Introduction of an innovation sets a chain of repercussions throughout the learning milieu effecting a number of variables in the environment which in turn affect innovation. West (1975), while giving an alternate strategy of evaluation, stresses that for a comprehensive evaluation of innovation it is pertinent to study the innovation as a part of the context in which it operates.

He named it as context evaluation and describes its function as:

> "essentially concerned with estimating the effect the implementation of a specific set of course proposals has had on the curriculum in general, together with the extent to which the course proposals have themselves been modified by the school" (West (1975) pp.33-35)

For a contextual evaluation West (1975) considers there are seven important areas of inquiry, namely:

(i) effects on teaching and learning styles and methods;

(ii) effects on aims and objectives of the teaching staff;

(iii) effects on organisation of teaching groups;

(iv) effects on examinations and test procedures;

(v) effects on deployment, utilisation and training of staff;

(vi) effects on organisation of curriculum;

(vii) effects on the allocation and utilisation of resources.

Of these, four were judged to be pertinent for the purpose of the present study namely:

(i) effects on aims and objectives of the teaching staff.

(ii) effects on learning and teaching styles and methods.

(iii) effect on the allocation and deployment of resources.

(iv) effects on examination and assessment methods.

5.20. The lecturers priorities concerning the aims of practical work in Biology: Background

> "What a given teacher believes, knows and does along with what s/he does not believe, know and do will determine the form science education will take for a given student" (Hurd, Bybee Kahle and Yager (1980) p.359)

The key role a teacher can play in the success or failure of an innovation has long been recognised by the curriculum developers as well as evaluators as is apparent from the quote above.

Shulman (in Tamir et al. (1979)) recommends that,
any change in the curriculum should be mediated through the minds, motives and actions of the teachers. Feingold et al. (1979) quoted in Tamir (1979) advocated that teachers will adopt only those curricular innovations which are compatible with their philosophy and preferences.

The importance of teachers' recognition of, and acceptance of the philosophy of innovation makes it important to study teachers' views and priorities in order to gain an appreciation of the success or failure of an innovation. Parlett and Hamilton (1972) consider the study of teachers' views crucial to the assessment of the impact of innovations. West (1975) delineating different areas of inquiry for a comprehensive evaluation advocates,

> "central to such a study is the evaluation of the extent to which the explicit aims and objectives of a new curriculum have been accepted and internalised by the teaching staff, and the extent to which other, not necessarily older, aims have been superimposed on the curriculum". (West (1975) pp.35-36)

A comparison of teachers' priorities for the aims of instruction with the perceived achievements of these aims by students has been carried out by many researchers (Amos (1970), Boud et al. (1980), Jungwirth (1971), Kerr (1964), Lynch and Nydetabura (1982) and West (1973)). The studies have revealed many congruencies as well as disparities between the views of teachers and those of students. Lynch and Nydetabura (1982) compared the aims of practical work as seen by the teachers with the effect of practical work as viewed by students. These researchers found that there were disparities between what is thought to be of importance by the teachers and what is thought by students to be achieved. Jungwirth (1971) studied and compared teachers' own priorities with those of their students. He found there were disparities between them, including the fact what the teachers claimed as their priorities were different from those which their students thought were their teachers' priorities. In fact, he found there was considerable degree of similarity between the students' own priorities and those which they perceived to be their teachers' priorities. Dowd and Dekkers (1980) also found disparities between teachers' own priorities and students' opinion of their teachers' priorities. The study revealed that teachers are not always emphasising the objectives which they consider to be important. There are other similar studies (Amos (1970), and Tamir and Zoor (1977)) suggesting that comparative studies of teachers' priorities concerning aims and objectives of courses and their students' views reveal disparities which may assist both teachers and curriculum developers diagnose weaknesses and deal with them (Tamir and Zoor (1977)).

In view of the recommendations of proponents of evaluation models (West (1975), Parlett and Hamilton (1972)) and also the research findings cited in the literature, it was considered pertinent to explore both lecturers' and students' views on the subject of aims for practical work in biology.

For the purpose of the present study it was also decided to find out whether the priorities held by the lecturers are consonant with the priorities of the New Education Policy of Pakistan (1979) to establish what were students' views about the perceived influence of practical work in biology, and then, by studying the practices and performances of teachers and students, to establish the relationship between lecturers' priorities with regard to teaching science process skills and their practices in classrooms.

5.21. Method of study

West recommends, as an appropriate technique in investigating this sensitive area of enquiry, that of teachers' priorities regarding aims and objectives of instruction are studied by rating aims according to the relative importance given to them by teachers . This has been employed in a number of such studies including those of Amos (1970), Thompson (1975), Kerr (1964), West (1973)). This technique has also been used in this present study but is augmented with interviews with the lecturers.

In the first method a list of twenty aims for practical work in biology was given in a questionnaire to one set of lecturers who then were asked to rate each aim on a five point scale independently for its importance. In the second method used here a different set of lecturers were asked, during interviews with individuals to tell the researcher what they think should be the aims of practical work in biology at Intermediate level. They were asked to give their list of aims for practical work in biology, this list of aims not being in order of priority.

By using two techniques, and on different groups of lecturers, it is felt that it would be possible to determine whether or not items on the list of aims given in the questionnaire had imposed a constraint upon their choice.

5.22. The Sample

The information was gathered from the lecturers of biology currently teaching Intermediate classes, i.e. grade XI and grade XII classes, in colleges under six Boards of Intermediate and Secondary Education in the Punjab, in Pakistan, namely:

(i) Bahawalpur Board
(ii) Gujranwala Board
(iv) Lahore Board
(v) Multan board
(v) Rawalpindi Board
(vi) Sargodah Board

Since 1972 these six Boards have implemented a new biology curriculum for the Intermediate classes. For this curriculum the 1968 edition of the American BSCS, Yellow version 'An inquiry into life' has been prescribed as the official text materials.

The researcher contacted each of these Boards and asked them for a full list of their colleges which cater for Intermediate biology classes. Full lists were kindly provided by each of the Boards. Altogether there were found to be 224 colleges in these six Boards.

A structured sample of colleges under each of the six Boards was obtained in an attempt to include in it approximately 10% of each type of college. In fact a sample of 33 colleges out of a total of 224 was obtained by this means (an approximately 15% sample). Two questionnaires were sent by post to each of these 33 colleges and 38 of the 66 questionnaires were completed and returned. This is a response of 58%, which according to Oppenheim (1966) is a good response for a survey by postal questionnaires.

The colleges were then classified into one of four groups according to their type, namely:

(i) Intermediate college for boys
(ii) Intermediate college for girls
(iii) Degree college for boys
(iv) Degree college for girls.

(A description of each type of college is given in Chapter 1.)

The two copies of the questionnaire sent to each of the 33 colleges were addressed to the heads of the biology departments. The heads were requested to hand over the questionnaire to the biology lecturers currently teaching biology to Intermediate classes and who were willing to spare their time to fill in the questionnaire and return them to the researcher in the stamped addressed envelope that had been provided for the purpose.

5.23. The list of aims used

A survey of the literature was carried out to compile a list of aims for practical work in biology. Many such lists were found in the out- lines of science courses such as Nuffield Science 11 to 16, and in research studies cited in the literature.

The lists used by Thompson (1975) and by Kerr (1964) were judged to be the most appropriate for the purpose of the present study. These lists were compiled originally to obtain information from science teachers of sixth forms in England and Wales in order to study their priorities for the aims in practical work in science. The lists were used on these occasions for all science subjects and the aims given in the list were not specific to a particular science subject. The studies, and particularly that of Thompson (1975), were aimed at finding out the impact of new developments in science education and in particular the emphasis on teaching by discovery and inquiry method intended to instil science skills and scientific attitudes.

A comparative study of the two lists suggested that most of the aims on Kerr's list were contained in Thompson's list. Thompson's list of twenty aims was quite detailed and contained most of the probable outcomes of the practical work in science. It was compiled specifically to discern different trends among the teaching staff regarding the aims for practical work in science.

For these reasons Thompson's list was judged to be the most appropriate list to use in the present study, and was adopted with only minor changes for use in Pakistan.

Changes were made in phrasing some aims, and one of the aims on Thompson's list was replaced by an equivalent aim on Kerr's list since the phrasing of the aim on Kerr's list was judged to be more appropriate. The changes in phrasing of some other aims was deemed necessary to make the statements more easily understood by the lecturers in Pakistan.

To further improve the list for use in Pakistan, a pilot study was carried out in order to find out possible ambiguities in phrasing, in format, and in lay-out of the questionnaire. The list, which was just one part of a larger questionnaire, was therefore sent to Pakistan to twelve biology lecturers who were teaching biology to Intermediate classes and to three science educationalists working in the Minsitry of Education and curriculum- development centres there. They were asked to fill in the questionnaire, to comment on its general lay-out and also on the phrasing of the statements used in the questionnaire.

All the people to whom the questionnaires were sent replied. They made extensive comments and suggestions which were most useful, especially as they revealed ambiguities which otherwise would not have been recognised. For instance, the phrasing used in one aim was said to be unfamiliar and difficult. In the light of such comments and suggestions, changes were made and easier and more familiar words were used wherever possible.

The lecturers and educationalists were also asked to add any aim(s) to the list that they thought necessary. The aims that were added were thought to be already included in the list, and so no additional aims were judged to be necessary.

Before sending out the questionnaire for the final study, the revised version of the questionnaire was subjected to a second pilot study with a further five lecturers and one science educationalist from the first pilot study. This was to ensure that the changes made in the questionnaire had not introduced any other ambiguities and problems in understanding.

The lecturers and the educationalists in the second pilot approved the questionnaire and did not suggest any further changes relevant to the purpose of the present study, and so no more changes were felt necessary. After the second pilot study the questionnaires were sent for final study. Before the questionnaire was sent out for the final study the aims contained in it were classified into one of the three groups namely: process- based aims or content-based aims or general-aims.

The aims which were relevant to learning facts or principles and/or the clarification and verification of theory were classified as content- based aims, of which there were four. They are written out in Table 5.1 as aims C1, C2, C3 and C4.

Aims which were relevant to processes of science and related attitudes were classified as process aims. Nine aims in the list were so classified six of them being directly relevant to science process skills such as skill of observation, communication.

TABLE 5.1: List of Aims for Practical Work in Biology.

Key:- P = Process-based aims. C = Content-based aims. G = General aims.

	DESCRIPTION OF AIMS	CODE GIVEN TO EACH AIM.
	Content-Based Aims	
1.	To make biological phenomena more real through actual experience.	C1
2.	To help remember facts and principles.	C2
3.	To clarify theory so as to aid in understanding.	C3
4.	To verify facts and principles already taught.	C4
	Process-Based Aims	
5.	As a creative activity.	P1
6.	To give training in problem solving.	P2
7.	To develop simple common sense scientific method of thought.	P3
8.	To encourage accurate and careful observation.	P4
9.	As an integral part of finding facts and arriving at principles.	P5
10.	To develop an ability to understand and carry out instruction.	P6
11.	To develop personal characteristics such as independent thought, resourcefulness, reliability and responsibility.	P7
12.	To develop an ability to convey knowledge of biology by speech or writing.	P8
13.	To develop a critical attitude.	P9
	General Aims	
14.	To indicate relevance of knowledge to real life.	G1
15.	To arouse and maintain interest in the subject.	G2
16.	To develop an ability to handle apparatus skilfully.	G3
17.	To develop certain disciplined attitudes.	G4
18.	To develop ability to cooperate with others.	G5
19.	To give opportunity to practise standard techniques.	G6
20.	To prepare for practical examination.	G7

The remaining three aims in this group were relevant to the attitudes considered in the literature (Seymour et al (1974) and Brandwein et al. (1962) either as an outcome of process-based learning or conducive to process-based learning. They are written as P1 to P9 in Table 5.1. Seven aims on the list were such that cater for general skills and attitudes, and are grouped separately under the heading of general aims. They are given as G1 to G7 in Table 5.1.

The aims in each group have been given a code and a code number. All aims classified as content aims were coded as 'C' and each is given a specific number. The aims grouped under process aims were given a code 'P' and numbered. General aims were coded as 'G', each with a number.

The classification of these twenty aims and a brief description of each aim is given in the Table 5.1. However, the classification of these aims was not given to the lecturers. Instead they received a list of the aims which was randomly ordered. (See Appendix 5A).

5.24. Method of analysis of data

Lecturers were given the list of twenty aims for practical work in biology and were asked to rate the importance of each aim independently on a five-point scale. The responses were analysed to find out the order of importance given to each aim by the lecturers as a group, and to estimate whether or not the level of agreement among the lecturers concerning the rank order of aims was statistically significant and also whether particular factors - such as gender, age, length of teaching experience, previous training, and the type of college they teach in could be shown to have a significant effect upon their rating of aims.

(a) <u>Determination of the rank order of aims for practical work in Biology</u>

To obtain a measure of the relative importance of aims as viewed by the lecturers, the rank correlation method developed by Kendall (1962) was used.

Since each of the twenty aims was rated on a five point scale more than one aim could have the same score. For instance, one of the female lecturers gave the following rating to the aims:

Table 5.2 Rating given to each aim by a female lecturer.

Aims Number	● 1	* 2	≠ 3	● 4	● 5	* 6	* 7	● 8	≠ 9	* 10	● 11	● 12	● 13	● 14	≠ 15	≠ 16	● 17	≠ 18	≠ 19	● 20
Score	3	5	4	3	3	5	5	3	4	5	3	3	3	2	4	4	3	4	4	3
Rank	15	2.5	7.5	15	15	2.5	2.5	15	7.5	2.5	15	15	15	20	7.5	7.5	15	7.5	7.5	15

As is apparent from the rating, more than one aim have the same score. In this particular instance four aims are given the highest score of five (these aims are marked with an asterisk in the table) which means in rank order each of these aims will have a rank of 1. In computing the rank correlation, instead of giving the same rank to the entities having the same score, an average of ranks which they would have possessed if they were not tied is taken and allocated to each of the entities. In this particular instance, since four aims have a score of five, an average of the four ranks (i.e. 1 + 2 + 3 + 4 / 4 = 2.5) is taken and allocated to each of these aims.

In this example six other aims (marked with a 'not equal' sign in the Table 5.2) are given the next highest score which is a score of 4. Again an average of the ranks they would have had if they had not been given the same score is taken and allocated to each of these six aims rated as 4. Since the first four (1, 2, 3, 4) ranks have already been given to the aims scoring 5, the rank order of these next aims is from five to ten. So an average of 5 + 6 + 7 + 8 + 9 + 10 taken and the value obtained (7.5) is allocated to each of these aims.

Next, a group of nine aims is rated as 'important' i.e. given a score of 3. Once again, leaving the ranks already accounted for by the aims which scored 5 and 4, an average of the next ranks which are 11, 12, 13, 14, 15, 16, 17, 18, 19 is taken and the value (15) is allocated to each of the aims in this group. The remaining aim which is rated as 'not very important', is given the final rank of 20.

As is apparent from the table, there is an inverse relationship between the score and the mid-rank values.

(b) <u>Estimate of the consensus of opinion concerning the relative importance of the aims for practical work in Biology</u>

The non-parametric test Kendall's coefficient of concordance (W) was computed as an estimate of the extent to which there is a consensus of opinion among the lecturers on the relative importance of these aims. The coefficient can take a value between zero - indicating no agreement, and unity - indicating perfect agreement.

The Kendall's coefficient of concordance (W) is obtained from the equation:

$$W = \frac{S}{1/12\, K^3(N^2-N)} \qquad \text{(Siegul (1956))}$$

where

S is the sum of squares of the deviations of rank sum for each aim from the mean rank sum.

K is the number of ratings (38 in this case)

N is the number of the entities rated (the 20 aims in this case).

If there are ties in the rating then a correcting factor is added to the above equation:-

$$W = \frac{S}{1/12\, K^3(N^2-N)\, k\sum T} \qquad \text{(Siegul (1956))}$$

Where T is a measure of tying, in which T for ranking is computed as follows:

$$T = \frac{\Sigma(t^3 - t)}{12}$$

Where t is number of aims in each tied group, T being summed over all the ranking.

The significance of W is determined by computing X^2 and checking the value of a X^2 table with the number of degrees of freedom equal to N-1.

X^2 is computed by using the formula:

$$X^2 = K\ (N-1)\ W \qquad \text{(Siegul (1956) p.236).}$$

The results of this analysis are given in section 5.25.

5.25. The results

The rank order, mid-rank mean values and standard deviations of the aims obtained from 38 lecturers replies are given in Table 5.3. The Kendall's coefficient of concordance (W) gave a value of 0.10 which has a probability <0.01, showing that there is a significant degree of consistency in the rating of aims by the lecturers. It establishes that the rank order of aims, as derived from the rating of aims by the lecturers, is representative of the group's coherent opinion about the relative importance of aims for practical work in biology.

The relative positions of the aims in the rank order (see Table 5.3) reveal that the four aims that had been classified as content-based aims are all among the top ten. In contrast, the nine aims which had been classified as process-based aims all, except for two, appear among the bottom ten aims. The two exceptions are 'to encourage accurate and careful observations' which is on the second position in rank order and 'as a creative activity' which is tenth. A further look at the relative position of process-based aims shows that three of the nine process-based aims are given the least importance by the lecturers as they appear at the bottom-most positions in the rank order. These aims are 'to develop critical attitude', 'to develop an ability to convey knowledge' and 'as an integral part of finding facts and arriving at principles'.

TABLE 5.3: Rank Order of Aims Drawn From Lecturers' Ratings of Aims

Key:- C = Content-based aims; G = General Aims; P = Process-based Aims.

Rank Order	Mid-rank Mean Value (S.D.)	Description of Aims	Code C	Code P	Code G
1.	8.03 (±5.47)	To make biological phenomena more real through actual experience.	C_1		
2.	8.14 (±4.16)	To encourage accurate and careful observation and recording.		P_4	
3.	8.24 (±4.65)	To enable to handle apparatus skilfully.			G_4
4.	8.55 (±4.49)	To help pass examination.			G_7
5.	8.55 (±4.24)	To clarify theory so as to aid in understanding.	C_3		
6.	9.01 (±4.94)	To help remember facts and principles.	C_2		
7.	10.00 (±5.00)	To develop an ability to cooperate with others.			G_5
8.	10.34 (±5.08)	To verify facts and theory taught.	C_4		
9.	10.39 (±5.36)	To indicate relevance of knowledge to real life.			G_1
10.	10.47 (±5.90)	As a creative activity.		P_1	
11.	10.61 (±5.35)	To develop personal characteristics such as independent thought, self reliance, responsibility.		P_7	
12.	10.88 (±4.83)	To develop ability to understand and carry-out instructions.		P_6	
13.	10.95 (±5.68)	To develop simple common-sense scientific method of thought.		P_3	
14.	11.17 (±5.15)	To give training in problem solving.		P_2	
15.	11.26 (±5.14	To maintain and arouse interest in the subject.			G_2

CONT'D ...

TABLE 5.3: Rank Order of Aims Drawn From Lecturers' Ratings of Aims (Continued)

Key:- C = Content based aims; G = General aims; P = Process based aims

Rank Order	Mid-rank Mean Value (S.D.)	Description of Aims	Code C	Code P	Code G
16.	11.51 (±5.80)	To develop certain disciplined attitudes.			G_3
17.	12.07 (±4.77)	To give opportunity to practice standard techniques.			G_6
18.	12.37 (±4.93)	To develop critical attitude.		P_9	
19.	13.37 (±5.02)	To develop an ability to convey knowledge.		P_8	
20.	14.08 (±4.64)	As an intergral part of finding facts and arriving at principles.		P_5	

5.25.1. Results of the test of the differences between the sub-groups of lecturers

The data obtained were further analysed to explore if there was evidence of the effect of such variables as gender, age, length of teaching experience, previous training, and type of the college on lecturers' opinions about the aims of practical work in biology. Research studies cited in the literature have shown different results. For instance, Amos (1970) in a study of biology teachers' opinions about the importance of scientific method found that the length of the teaching experience was the most important variable to study. Blakenship (1965), in his research on teachers' attitudes about the BSCS programme found similar results; his study revealed that the less experienced teachers had more a favourable attitude towards the programme. Thompson (1975), however, in a study about teachers' perceptions of the aims of practical work in science found that these variables had very little effect on teachers' perceptions and generally there was a considerable degree of similarity amongst different groups of biology teachers. In view of these findings and of other research studies carried out elsewhere, it was considered worthwhile to further analyse the data to study the effect of the variables on lecturers' perceptions of the aims for practical work in biology.

Altogether five variables were identified which might have an affect on the lecturers' opinions namely, gender, age, type of the college, previous training and length of the teaching experience.

The priorities of each group of the lecturers were compared by drawing up a rank-ordered list of aims from the rating of aims by each member of the group. This was achieved by using Kendall's coefficient of concordance (W). It was then tested for significance. Spearman's coefficient of correlation (p) was computed to test the correlation between ranking of aims by comparable groups of lecturers. The difference between ranks of individual aims was tested for significance using the Mann Whitney test (U) (see the results in Table 5.4).

Sample size was too small to analyse the data further.

TABLE 5.4: Tests of significance.

Key:- W = Kendall's Coefficient of concordance. p = Spearman's coefficient of correlation

Variables Studied.	Names of the group of lecturers under each variable and Size of each group.	Values obtained from tests of significance of:-				
		W	X^2	Probability	p	Probability
Gender	Female (11)	0.171	35.810	<0.05	0.547	<0.01
	Male (27)	0.110	56.459	<0.01		
Subject of Specialisation	Zoology (22)	0.103	43.086	<0.01	0.666	<0.01
	Botany (14)	0.129	34.203	<0.05		
Type of College	Intermediate College (10)	0.196	37.196	<0.01	0.473	<0.05
	Degree College (28)	0.104	55.150	<0.01		
Length of teaching experience	0-10 Years (20)	0.128	47.089	<0.01	0.480	<0.05
	11-15 Years (18)	0.146	50.042	<0.01		
Age in Years	35 and Less (20)	0.140	53.038	<0.01	0.395	<0.05
	36 and Above (18)	0.160	54.797	<0.01		

5.25.2. Comparison of priorities of male and female lecturers

The extent of agreement on the relative importance of aims within each group of the lecturers was tested with Kendall's coefficient of concordance (W). For male lecturers the value of W was obtained 0.11 which is statistically significant ($p<0.01$). For female lecturers the value of W obtained was 0.171, which is also statistically significant ($p<0.05$).

The rank order of aims drawn up for male and female lecturers is shown in Table 5.5. The significant value of Kendall's coefficient of concordance establishes that the rank order of aims drawn up for each of the two groups of lecturers does represent a coherent view of the members of the respective groups.

Spearman's coefficient of correlation (p) was used to gain a measure of the correlation between the two rankings of aims. A value of p = +0.547 was obtained which is statistically significant ($p<0.01$), leading to the conclusion that there is a positive and significant correlation between the male and female lecturers' views.

Table 5.5 shows that though there is a positive and statistically significant correlation in overall ranking of aims of practical work by the two groups, the rank order of the aims on the two lists is not identical. There is just one aim for which there is a unanimity of opinion between the two groups, while for remainder difference in the rank order of the aims varies from just two positions to as many as eleven positions.

Table 5.5: Rank order of aims drawn for male and female lecturers of biology

Key:- Aims with star are rated significantly highly at $p<0.05$ as tested by Mann Whitney U test.

	DESCRIPTION OF AIMS	Rank order	
		Male n = 27	Female n = 11
	Content Based Aims		
1.	To make biological phenomena more real through actual experience.	2	5
2.	To help remember facts and principles.	6	4
3.	To clarify theory so as to aid in understanding.	1	12
4.	To verify facts and principles already taught.	11	7
	Process Based Aims		
*5.	As a creative activity.	15	2
6.	To give training in problem-solving.	8	17
7.	To develop simple common sense scientific method of thought.	13	11
*8.	To encourage accurate and careful observation.	5	1
9.	As an integral part of finding facts and arriving at principles.	20	20
10.	To develop an ability to understand and carry out instruction.	10	14
11.	To develop personal characteristics such as independent thought, resourcefulness, reliability and responsibility.	7	15
12.	To develop an ability to convey knowledge of biology in writing or speech.	19	18
13.	To develop a critical attitude.	17	19
	General Aims		
14.	To indicate relevance of knowledge to real life.	9	10
15.	To arouse and maintain interest in the subject.	16	9
16.	To develop an ability to handle apparatus skilfully.	3	6
17.	To develop certain disciplined attitudes.	1	13
18.	To develop ability to cooperate with others.	12	3
19.	To give an opportunity to practice standard techniques.	18	16
20.	To prepare for practical examination.	4	8

The Mann Whitney U test was used to test for statistically significant differences in ranking of individual aims. The results obtained show that the difference reaches the level of statistical significance in only three cases ($p<0.05$). Female lecturers rank two of the nine process based aims significantly higher than do the male lecturers. These aims are 'as a creative activity' and 'to enable to make accurate and careful observations and recordings'. The former is second in rank order on the list for female lecturers and fifteenth in rank order on the list of male lecturers. Female lecturers also rate the general aim, 'To develop habit of cooperation with others' significantly higher than do the male lecturers.

The results show that there is a consensus of opinion amongst female and amongst male lecturers and that the overall rank order of aims of the former is not statistically significantly different from that of the latter. Three individual aims, two of them process aims, are ranked statistically significantly higher by female lecturers than by male lecturers.

Table 5.5 shows that both groups rate highly three out of the four content-based aims for these are among the top ten aims on both lists. In contrast, five out of nine process-based aims are among the bottom ten aims on the list of female lecturers whereas on the list of male lecturers seven out of these nine aims are among the bottom ten aims of the rank ordered list.

The general aims are treated similarly by both male and female lecturers. On both lists the aims, 'to enable to use apparatus skilfully' and 'to help pass practical examination', are among the top ten aims of the lists, while aims ' to develop certain disciplined attitudes' and 'to give opportunity to practice standard techniques' are among the bottom ten aims of both lists.

In view of the type of the aims which are among the top priorities of the male and female lecturers as suggested by the relative positions of aims on the two rank ordered lists, it would seem that main emphasis of both groups is on content, manipulative and observation skills. The aim 'to enable to pass examination' is also given considerable importance. In view of these results it seems reasonable, therefore, to expect these priorities to show through in their styles of teaching, and this is investigated in section 5.30.

5.25.3. Comparison of priorities of lecturers having M.Sc. in Zoology with those having M.Sc. in Botany

Most of the lecturers who teach to Intermediate classes have either an M.Sc. in Zoology or an M.Sc. in Botany, for a very few indeed, and in fact only two lecturers in a sample of thirty eight lecturers, have an M.Sc. in Biology.

Botany and zoology are two separate disciplines and it might be that lecturers who have their training in zoology have different priorities for practical work as compared to those who have their training in botany. To test whether or not the subject of specialisation has any such effect the sample was divided into two sub-groups according to training, and rank-ordered lists of aims were drawn from the rating given to each aim by each member of the two groups, again using the mid-rank mean method.

A summary table of the results is given in Table 5.6. The Spearman's coefficient of correlation p was computed as a measure of the correlation between these two rank order lists. A value of p = +0.66 is obtained which is statistically significant ($p<0.01$), establishing that there is a positive and significant correlation between the two rank ordered lists.

Table 5.6: Rank order of aims drawn for lecturers having M.Sc. in Zoology and Botany

	Description of aims	Rank order zoology n = 22	Rank order botany n = 14
	Content based aims		
1	To make biological phenomena more real through actual experience.	4	3
2	To help remember facts and principles taught in theory.	9	1
3	To clarify theory so as to aid in understanding.	5	4
4	To verify facts and principles already taught.	14	2
	Process based aims		
5	As a creative activity.	7	13
6	To give training in problem solving.	14	10
7	To develop simple scientific method of thought	12	11
8	To encourage accurate and careful observations.	1	6
9	As an integral part of finding facts and arriving at principles.	20	19
10	To develop an ability to understand and carry out instructions.	9	17
11	To develop personal characteristics such as independent thought, resourcefulness, reliability and responsibility.	11	11
12	To develop an ability to convey knowledge of biology in writing or speech.	18	20
13	To develop a critical attitude.	17	15
	General aims		
14	To indicate relevance of knowledge to real life.	5	16
15	To arouse and maintain interest in the subject.	16	9
16	To develop an ability to handle apparatus skilfully.	3	4
17	To develop certain disciplined attitudes.	6	18
18	To develop ability to cooperate with others.	13	8
19	To give an opportunity to practice standard techniques.	19	14
20	To prepare for examination	2	6

On that basis there is no evidence that the subject of specialisation, and hence the training experience of the lecturers, has any statistically significant effect on the overall priorities of the aims for practical work in Biology at Intermediate level. Indeed, with the correlation of coefficient as high as +0.666 and both positive and statistically significant, it suggests there is considerable agreement between the two groups of lecturers about the aims of practical work in biology.

However, this degree of agreement between the two groups is of little, if any, value unless there is also a significant degree of agreement within each of the two groups. To test the degree of agreement within each group Kendall's coefficient of concordance (W) was computed. A value of $W = 0.103$ was obtained for zoology lecturers and a value of $W = 0.129$ was obtained for botany lecturers, both values statistically significant ($p<0.01$ and $p<0.05$ respectively). So there is a statistically significant degree of agreement within each group as well as a statistically significant correlation between the two groups.

As might be expected, however, the ranks of aims on the two lists are not identical, and indeed the ranks on the two lists of all except one aim are different and this difference ranges from a difference of one place to a difference of twelve places on the lists.

The Mann Whitney U test was computed to test whether or not the difference in ranks of individual aims is statistically significant. On no occasion did the difference in rank reach a level of significance. Hence there is no reason to reject the null hypothesis namely, that the difference in ranks of individual aims on the two lists is no more than a matter of chance.

The results showed that both groups of lecturers give priority to content- based aims, and, with few exceptions they give low priority to process-based aims. On the whole the aims of 'clarification of theory to aid in understanding', 'skills of handling apparatus' and 'observation skill' are amongst the top-most priorities of both groups.

From these results it appears that the lecturers trained in botany or zoology have essentially the same views about the aims of practical work in Intermediate Biology.

5.25.4. Comparison of priorities of lecturers with different length of teaching experience

The teaching experience might be a potentially important factor in moulding a lecturer's views regarding the aims of practical work in biology at Intermediate stage. Taking experience of teaching as a criterion of grouping, the sample was divided into two groups, one composed of lecturers who have had an experience of teaching of biology up to ten years and the other composed of lecturers who have had an experience of teaching of eleven and more years. Since neither the gender nor the background training are significant variables the whole sample could be satisfactorily divided in this manner on this occasion.

The group which has up to ten years of experience has the experience of teaching Intermediate biology based only on BSCS materials, 'An inquiry into life', (Yellow version) for this group has never taught the old curriculum based entirely on materials written by Pakistani writers. The group which has an experience of teaching for more than eleven years would have teaching experience both of the old curriculum and the new curriculum - which was intended to be inquiry-based and for which BSCS materials were to be used.

The rank order of aims of the two groups is given in Table 5.7 Kendall's coefficent of concordance (W) computed to test for statistically significant agreement within each group gave values which are statistically significant ($p<0.01$) in both cases. So the rank ordered lists drawn up do represent the coherent opinions of each of the two groups.

The overall ranking of the twenty aims by the two groups of lecturers has a positive correlation as shown by Spearman's coefficient of correlation (p). The value obtained is 0.48 which is both positive and statistically significant ($p<0.05$). Hence there is a positive and significant correlation in the ranking by the two groups. The priorities held by two groups are shown to be similar.

Viewing the top most ten aims of the two rank-ordered lists reveals that both groups tend to give priority to content-based aims, and the skills of observation, and handling apparatus. The aim 'to help pass examination' is also given priority by both groups. However, in the case of lecturers with more than eleven years of teaching experience the aims 'as a creative activity' is given a higher rank than do the lecturers with less than eleven years of experience, and the difference is statistically significant as tested by the Mann Whitney (U) test ($p<0.05$). The high ranking of this aim is apparently inconsistent, for the process skills which are found to be conducive to creative enterprises are given low rankings.

These results do not suggest that the two groups differ from each other to any appreciable degree. As is apparent from the Table 5.7 all four content- based aims are in the top half of the table in contrast to six out of nine process-based aims which are among the bottom ten aims of the two lists. There is no evidence to suppose that different length of teaching experience has affected significantly lecturers' views in a manner which has changed their approach towards process-based aims of practical work in biology courses at Intermediate level.

Table 5.7: Rank order of aims drawn for lecturers having different length of teaching experience

	Description of aims	Rank order 0 - 10 n = 20	11- >15 n = 18
	Content based aims		
1	To make biological phenomena more real through actual experience.	7	1
2	To help remember facts and principles taught in theory.	4	8
3	To clarify theory so as to aid in understanding.	2	6
4	To verify facts and principles already taught.	11	7
	Process based aims		
5	As a creative activity.	19	2
6	To give training in problem solving.	13	12
7	To develop simple scientific method of thought	16	9
8	To encourage accurate and careful observations.	3	4
9	As an integral part of finding facts and arriving at principles.	20	20
10	To develop an ability to understand and carry out instructions.	10	11
11	To develop personal characteristics such as independent thought, resourcefulness, reliability and responsibility.	8	16
12	To develop an ability to convey knowledge of biology in writing or speech.	18	19
13	To develop a critical attitude.	14	18
	General aims		
14	To indicate relevance of knowledge to real life.	9	13
15	To arouse and maintain interest in the subject.	12	13
16	To develop an ability to handle apparatus skilfully.	17	10
17	To develop certain disciplined attitudes.	1	5
18	To develop ability to cooperate with others.	5	15
19	To give an opportunity to practice standard techniques.	15	17
20	To prepare for examination.	6	3

5.25.5. Comparison of priorities of lecturers teaching in Intermediate colleges with those employed in Degree colleges

Intermediate biology classes are held in two types of college namely, Intermediate and Degree colleges. Intermediate colleges cater for only higher secondary classes, i.e. grades xi and xii, while Degree colleges cater for grades xi and xii and for degree course i.e. B.A. and B.Sc. classes. Biology lecturers in Degree colleges teach both Intermediate and degree classes.

Viewing the difference in the two types of colleges and the fact that the Degree colleges are recipients of successful Intermediate students, it seems reasonable to expect a difference in the views of lecturers of these colleges with respect to the aims for the practical work at Intermediate level in Biology.

A summary Table 5.8 showing the rank-ordered list of aims for each of the two groups of lecturers is given. Kendall's coefficient of concordance (W) computed to assess the significance of agreement among the lecturers within each group gave values of 0.11 for Degree colleges and 0.196 for Intermediate colleges. Both values are statistically significant ($p<0.01$). There is a statistically significant degree of agreement within each of the two groups on the importance of aims for practical work in Biology at Intermediate level.

Table 5.8: Rank order of aims drawn for lecturers teaching in Intermediate and Degree colleges

	Description of aims	Rank order I n = 10	Rank order D n = 28
	Content based aims		
1	To make biological phenomena more real through actual experience.	7	1
2	To help remember facts and principles taught in theory.	1	7
3	To clarify theory so as to aid in understanding.	2	6
4	To verify facts and principles already taught.	10	10
	Process based aims		
5	As a creative activity.	20	5
6	To give training in problem solving.	13	13
7	To develop simple scientific method of thought	14	11
8	To encourage accurate and careful observations.	3	3
9	As an integral part of finding fact sand arriving at principles.	18	20
10	To develop an ability to understand and carry out instructions.	17	8
11	To develop personal characteristics such as independent thought, resourcefulness, reliability and responsibility.	12	9
12	To develop an ability to convey knowledge of biology in writing or speech.	19	19
13	To develop a critical attitude.	15	17
	General aims		
14	To indicate relevance of knowledge to real life.	6	14
15	To arouse and maintain interest in the subject.	10	16
16	To develop an ability to handle apparatus skilfully.	8	2
17	To develop certain disciplined attitudes.	16	15
18	To develop ability to cooperate with others.	4	12
19	To give an opportunity to practice standard techniques.	9	18
20	To prepare for examination	5	4

Spearman's coefficient of correlation (p) was then computed to assess the correlation in the overall ranking of aims between the two groups. A value of 0.743 was obtained which is positive and statistically significant ($p<0.05$). This reveals that there is a statistically significant agreement in priorities of the two groups of lecturers concerning the aims of practical work in Biology at Intermediate level.

The summary table (Table 5.8) shows that four aims have identical ranks on the two lists and the rest have different ranks the difference ranging from one place to fifteen places.

The Mann Whitney (U) test was used to test if the difference in the ranking of individual aims was statistically significant. In just two cases it is statistically significant and these show that the lecturers teaching in Intermediate colleges give significantly more importance to the use of practical work for helping students to remember facts and principles, and to clarify theory taught in theory lessons than do the lecturers in the Degree colleges. But this difference in ranking of content-based aims does not suggest that the Degree college lecturers give any particular importance to process-based aims as these aims are still among the bottom ten aims of the rank ordered list drawn for Degree college lecturers.

The content-based, process-based and general aims are similarly distributed in the two lists indicating a similar approach of the two groups regarding practical work in biology.

Both groups of lecturers give comparatively little importance to the aims 'to give training in problem solving skills' and 'as a part of finding facts and arriving at principles' and 'to enable to communicate' and 'to develop a critical attitude, and disciplined attitude'. These process-based aims have the lowest priority in both lists.

On the other hand, the aims at the top of the two lists are again similar and tend to concentrate upon content-based aims and upon general aims dealing with manipulative skills and ones which help students to pass examinations.

The differences in priorities do not show either group to be more noticeably pro-process in its teaching than the other. They also indicate that, on the whole, both groups are pro-content in their approach to the teaching, with, if anything, Intermediate college lecturers are even more pro-content in their approach than Degree college lecturers.

5.26. Aims for practical work: the results of interviews with lecturers of EPB and BSCS-user colleges

Semi-structured interviews were held individually with the lecturers from the colleges previously identified as EPB-user and BSCS-user colleges.

In EPB-user colleges (n=16) most of the lecturers who are currently teaching Intermediate classes were interviewed. Only in one case did the lecturer refused to spare her time. Altogether 42 lecturers' views were obtained on this issue. In BSCS-user colleges (n=6) the teaching staff was large and all the lecturers could not be contacted. Four among those who could be contacted refused to spare their time, one of them did not think he had anything to say, since he thought things were working well. Altogether 20 lecturers were interviewed.

The lecturers were asked to indicate what, in their opinion, should be the aims for practical work in Biology at Intermediate level. The aims that they spoke of were recorded in the same phrases that they used. The aims that they gave were not given in any particular order of priority.

The lists obtained were then studied and it was found that some were essentially variants of the same aim. For instance, some lecturers mentioned the aim, 'to enable the students to use the microscope' while others said 'to enable the students to use apparatus'. Since both phrases are concerned with the use of the apparatus then they were classed as being equivalent to each other, both being considered to be instances of the aim 'to enable to use apparatus skilfully'.

In this manner all the replies were analysed and classified. The aim mentioned by only one lecturer were set aside and are not considered further, with the result that thirteen different aims emerged from the lecturers' replies.

The number of lecturers both in EPB-user and BSCS-user colleges who mentioned each aim was calculated. The thirteen aims emerging from the lecturers' replies were rank ordered according to the number of lecturers who mentioned them. The aims mentioned by more lecturers were given higher ranks than those meentioned by fewer

Each of the aims emerging from the lecturers' replies was also classified into one or the other of the major types of aims namely:

content-based aims, process-based aims and general aims.

The results from the replies of the lecturers from EPB-user and BSCS-user colleges are discussed on the following pages.

5.26.1. Comparison of the views of the lecturers from BSCS-user colleges with those from EPB-user colleges

The two lists of aims emerging from the replies of the lecturers from BSCS-user colleges and those from EPB-user colleges are with the few exceptions strikingly similar. In fact, only three aims mentioned by one group and not mentioned by the other group of lecturers. It suggests that the prevailing aims of the practical work in biology held by the lecturers from the two types of the college namely EPB-user and BSCS-user colleges are essentially the same.

However, the frequency of occurence of different aims is different in two types of the colleges as would be expected and as is apparent from the Table 5.9. Consequently, the ranks of aims, which are dependent upon the frequency of occurence, are also different on the two lists.

To test for the correlation between the ranks of aims on the two lists Spearman's coefficient of correlation (p) was used and gave a value of +0.65, which is positive and statistically significant ($p<0.01$). A positive and statistically significant value shows there is a consistency of view about the aims for practical work in biology at Intermediate level amongst the lecturers in the two types of the college.

Table 5.9. Percentage frequency and rank order of aims discerned from the replies of the lecturers from EPB and BSCS-user colleges

Code	Description of aims	EPB users Frequency	EPB users Rank order	BSCS users Frequency	BSCS users Rank order
P	To develop ability to observe.	7	10	80	1
C	To further explain theory.	76	1	65	2
G	To enable to use apparatus.	55	2	50	3
C	To impart knowledge of flora and fauna.	17	6	35	4
P	To develop creative abilities.	12	9	30	5
P	To develop scientific attitude.	0	12	25	6
G	To enable to perform experiments.	31	4	25	6
C	To help remember facts and principles.	33	3	20	8
G	To give training in dissections.	19	5	20	8
C	To explain relationship of structure and function.	0	12	10	10
P	To enable to classify plants and animals.	14	8	10	10
G	To give training in section cutting and staining.	17	6	10	10
P	To develop curiosity.	5	11	5	13

Key:- C = Content-based aims
G = General aims
P = Process-based aims

A comparison of the rank-order of the aims on two lists shows that out of seven top most aims of the rank-ordered lists four aims are the same namely, 'to develop power of observation', 'to further explain the theory taught in theory lessons', 'to enable the students to use apparatus properly', and the aim 'to enable the students to perform the experiment properly.' It indicates that the most prevalent aims for the practical work in biology at Intermediate level are essentially the same in two types of the college.

As could be expected there are differences in the ranks in the case of a few aims , which are of interest. The lecturers from BSCS-user colleges mentioned the aims 'to study the flora and fauna of Pakistan', 'to develop creative abilities', 'to develop scientific attitude', more frequently than the other aims since these aims are amongst the top most seven aims on the list from lecturers in BSCS-user colleges. In EPB-user colleges these aims were either rarely mentioned or were not mentioned at all as is apparent from their low ranks on the list of aims drawn from lecturers in for EPB-user colleges. On the other hand, there are some aims which were mentioned more frequently in EPB-user colleges than in BSCS-user colleges. These aims are, 'to help students to learn terms, fact and principles' 'to give training in dissections' and 'to verify theory taught'. These aims are amongst the top most seven aims on their list, while on the list of the lecturers from BSCS-user colleges these are amongst the bottom seven aims. The nature of the data is such that it does not lend itself to a statistical test for significance in difference between ranks of the individual aims. All that can be derived from these results is that in EPB-user colleges lecturers would appear to give more attention to theoretical aspects of biology than do the lecturers in the BCSC-user colleges, while in

BSCS-user colleges there is some recognition of some of those attitudes which are given priority in the Education Policy (Government Report (1979)) while in EPB-user colleges these aims, as their frequency of occurence suggests, do not seem to be given much attention.

Although the results obtained show some striking similarities and differences in the views of the lecturers they do not suggest that either of the two groups give particular attention to science-process skills except for the two skills namely, skill of observation and skill of classification. However, in BSCS-user colleges there is some recognition of attitudes relevant to process-based teaching as the top-most positions of the aims such as scientific attitudes and creativity suggest. In EPB colleges there is little evidence of any recognition of process-based aims other than those of observation and classification.

The results obtained from the interviews suggest that the prevailing views about the aims for practical work in biology in the two types of college are essentially the same in that there is no evidence to suggest that there is any appreciable difference in the overall approach of the two groups of lecturers.

The results obtained from the questionnaire and from the semi-structurerd interviews are similar so there is no reason to believe that the twenty aims having been presented to the lecturers in the questionnaire affect lecturers' views about the aims of practical work in biology.

There is a consistency in the prevailing views about the aims of practical work in Biology at Intermediate stage and the lecturers give priority to observation skills, manipulative skills and teaching of content over process skills.

5.27. The usefulness of practical work in biology: students' views

Discovering the views of participants is crucial to an assessment of the impact of an innovation (Lewy (1977)). Students are one of the major participants of the curriculum and so it is pertinent to seek their views concerning their own abilities and attitudes. Early in the life history of evaluation studies there was a tendency to use students as guineapigs to assess the achievement of objectives (Lewy (1977)). Later experience showed that "though we do not necessarily view students as experts on curriculum materials, the students who have tried to learn from new materials and procedures are often very good observers of their own problems and reactions" (ibid.). Lynch and Nydetabura (1982), in a study of teachers' perception of aims of practical work and students' views on the influence of practical work, concluded that much more consideration should be given to the perception of students as a starting point for curriculum evaluation. Findings from other research studies suggest that studying the issue from both the teachers' and the students' point of view helps illuminate aspects of the curriculum in practice that fail to emerge when information is gathered from only one of these groups (for instance, Amos (1970), Dowd and Dekkers (1980) and Jungwirth (1971)).

In the light of such findings an appraisal of students' views was considered pertinent and informative for the purpose of the present study.

Students, some in the first year and some in the second year of the Intermediate biology course, were given eight of the twenty aims that had been incorporated into the questionnaire given to the lecturers. This selection was based partly on Kerr's (1965) list of aims which he gave to the students in his study and partly on the researcher's own judgement on the basis of previous experience of what would be easy for Intermediate students to understand and answer fully. The aims included in the list, and the instructions, were given in both english and urdu for convenience of the students from english-medium schools and for those from urdu-medium schools.

The students were given the list of eight aims and were asked to indicate how useful they thought their practical work in biology was for each of the eight aims independently. They were given a five-point scale to indicate their views.

1. Very useful
2. Useful
3. Moderately useful
4. Slightly useful
5. Not at all useful

The list was subjected to a pilot study on 14 students from 7 colleges who were then excluded from the final study. The pilot questionnaire was administered personally and 14 volunteer students, two from each college, filled in the questionnaire independently and individually. Students from Intermediate and Degree colleges and from boys' and girls' colleges were included in the pilot study. Students' replies to the questionnaire showed that the eight aims included in the questionnaire were found easy by the students to give their judgements.

Discussion held with the students also revealed that they found none of the statement of the aims difficult to understand nor did they have any difficulty in understanding the instructions.

In the final study data were collected from the students in the Intermediate and in the Degree colleges and in both boys' and girls' colleges.

The sample was an opportunity sample. It was noticeable that students from BSCS-user colleges showed more interest in this particular aspect of the study and in filling in the questionnaire than did the students from EPB-user colleges.

The final questionnaires were administered in each college personally by the researcher during college hours. Students who volunteered to spare their time were gathered in a classroom separate from the rest of the class and were asked both verbally and in the questionnaire to fill in the questionnnaire independently and individually. In all but one college the lecturer in charge of the class left the students and researcher while the students were filling in the questionnaire.

Altogether 279 students filled in the questionnaire, 76 students from 5 BSCS user colleges and 203 students from 16 EPB user colleges. An average 15 students from each college filled in the questionnaire.

The key was given in descending order of importance following the key given to the students by Kerr (1964). A copy of the students' questionnaire is given in the Appendix 5B. From students' replies a rank order of the aims was derived using Kendall's (1962) mid-rank mean method.

5.27.1. Views of students from EPB-user colleges

The rank-ordered list of aims (Table 5.10) drawn from the replies of the 203 students from EPB colleges shows that these students judge their practical work in biology to be of relatively more use for four aims namely:

- to arouse and maintain interest in the subject
- to encourage accurate observations
- to clarify theory so as to aid in understanding
- to enable to use apparatus skilfully.

These students consider their practical work of comparatively less value for aims relevant to:

- passing examination
- development of habit of independent thinking, self reliance and resourcefulness
- to help remember facts and principles
- to develop a critical attitude.

The practical work has been found least useful for the aim 'to develop a critical attitude' as this is the last aim on the rank ordered list of aims drawn up from these students replies.

These results were taken to mean that in EPB-user colleges the students judge their practical work to be of relatively little value for remembering facts and for the development of attitudes conducive to inquiry-based learning.

5.27.2. Usefulness of practical work in biology: views of students from BSCS-user college

The rank ordered list of aims drawn from the replies of the students from BSCS- user colleges is given in the Table 5.10. The relative position of aims on the lists shows that the practical work in biology, as done in BSCS-user colleges, is judged to be of relatively more value for the aims:

- to develop skills in handling apparatus
- to enable to make accurate and careful observations
- to help pass examination
- to help remember facts and principles.

While the students judge their practical work to be relatively less useful for the aims:

- to maintain interest in the subject
- to help to clarify theory
- to develop habit of independent thought, self reliance, resourcefulness
- to develop a critical attitude.

The practical work is considered of comparatively little value for the process-based aims conducive to inquiry-based learning, as is apparent from low ranks of the aims relevant to critical attitude and habit of independent thought.

There is no evidence that in BSCS-user colleges practical work is causing the students to be particularly aware of the role of practical work in developing aims conducive to inquiry-based learning.

5.27.3. Comparison of the views of students from BSCS-user colleges with those from EPB-user colleges

The two rank-ordered lists of aims derived from the replies from the students from BSCS-user colleges and those from EPB-user colleges are set out for comparison in the Table 5.10. The Spearman's coefficient of correlation (p) value (0.42) did not reach the level of statistical significance and so there is no evidence to reject the null hypothesis namely, that the difference in ranking of the overall aims is simply a matter of chance.

Table 5.10. Rank-order and mid-rank mean values of aims drawn from rating of each aim by the students of BSCS and EPB-user colleges

Code	Description of Aims	Rank order of aims on the list of students from the colleges of EPB-Users n=203	BSCS-Users n=76
G_2	To arouse and maintain interest in the subject	1 (4.00)	5 (4.49)
P_4	To encourage accurate and complete observation	2 (4.11)	2 (4.05)
C_3	To clarify theory so as to aid in understanding	3 (4.16)	6 (4.55)
G_4	To enable to use apparatus skilfully.	4 (4.21)	1 (4.00)
G_7	To help pass examination	5 (4.31)	3 (4.19)
P_6	To develop habits of independent thought	6 (4.75)	7 (5.10)
C_2	To help remember facts	7 (4.88)	4 (4.29)
P_8	To develop a critical attitude	8 (5.58)	8 (5.31)

Key:- C = Content-based aims
G = General aims
P = Process-based aims

However, the results 3 individual aims are of particular interest. It is interesting and encouraging that EPB-users found their practical work helpful in maintaining and arousing their interest in the subject. However, it is surprising that BSCS-users did not find their practical work of much value in this respect.

It is surprising and unexpected that EPB-users did not find their practical of much value in helping them to remember facts while BSCS-users did find it useful for remembering facts. It is also unexpected and surprising that EPB-users found their practical work of more value to understand the theory than do the BSCS-user students. However, it is quite understandable, and is also in consonance with the views of the lecturers, that practical work in biology is not found of much value in developing critical attitudes and habits of independent thought. It also reinforced the finding that at present practical work is perceived more as an aid in teaching content than as a mean to develop science process skills and attitudes.

5.27.4. Comparison of students' views with the lecturers' views

A comparison of the views of lecturers about the relative importance of these eight aims of practical work in biology are compared with the students' views about the value of practical work in order to find out if the aims considered important by the lecturers are the same or different from those for which students judge their practical work to be relatively more useful.

The comparison (Table 5.11) reveals that, although the views of the two groups are not essentially similar on each aim, there are a few aims for which the views of the two groups are strikingly different.

Table: 5.11. Comparison of rank order of aims by students and lecturers

Aims	Rank order of aims Lecturers	Students
To help remember facts and priciples.	5	7
To clarify theory to aid in understanding.	2	3
To develop skills in handling apparatus.	2	4
To arouse and maintain interest in the subject.	7	1
To help pass examination.	4	5
To encourage accurate obsevations.	1	2
To develop habit of independent thought.	6	6
To develop critical attitude.	8	8

The lecturers give relative importance to the aims 'to develop skills in handling apparatus' and skill of 'observation', and also to the aims relevant to teaching content of biology. These are the aims for which students also value their practical work.

The aims relevant to development of habit of independent thinking, self reliance, resourcefulness and critical attitude are given relatively less importance by the lectures since these aims are at the bottom fo their rank ordered list. Students' judgement of usefulness of their practical work for these aims indicates that the practical work in biology as done in their classes also relatively unimportant for the achievement of these aims.

These results suggest that there is a striking consistency in prevailing perceptions and use of BSCS or EPB materials is not making any appreciable difference to perceptions concerning the value of process-based aims.

5.30. Teaching practices used in Intermediate Biology laboratories

The introduction of new curricula often suggest new methods of teaching and learning (West (1975)). BSCS curricula of the 1960s were new in their concept and purpose and needed to be taught in a manner and style that may be quite different from those used in teaching conventional curricula (Hurd (1964)). A full implementation of a new curriculum requires the teachers to adopt such new teaching strategies, and for the assessment of the success or failure of innovations, a study of classroom transactions has been given a place of prime importance in many curriculum evaluation strategies such as those suggested by Brown (1978), Lewy (1972), Parlett and Hamilton (1972), Eisner (1985). It has also been recommended by many researchers, for instance by Eggleston and Galton (1976), Kempa (1979) and West (1975) as important areas of investigation to assess the extent to which the methods and strategies recommended by innovators have been implemented in the classrooms (Brown (1978)). 'The classrooms and the science laboratories are key places where curriculum intentions are translated into action, involving both the teacher and the learner, designed to bring about the effects which the curriculum set out to bring about' (Kempa (1979) p.51). There is a possibility that some teachers teach the "new programme" just like another textbook without adopting the approach advocated by the new curriculum.

Findings from many research studies confirm the view. For instance in a study of teaching methods used in science classes in England, Eggleston et al.19 , found that science teachers, particularly biology teachers rarely used the methods indicative of the Nuffield approach (Eggleston et al. (1971)). Gallaghar in his study of biology classes using the BSCS Blue version, found that different teachers were teaching the same topic (Photosynthesis) in different ways (Gallaghar (1967)).

The BSCS materials in use in Pakistan are inquiry-based and require the teaching strategies to be different from conventional text.

For the purpose of the present investigation, it was decided to study the teaching methods used in biology practical classes so as to gain appraisal of the extent to which BSCS-user and EPB-user lecturers give attention to science process skills in their practices.

Approaches used by researchers to study classroom transactions and teaching and learning methods vary from simple recording and reporting of the events as they occur to more systematic methods like questionnaires, interviews and category systems. Observation schedules and category systems have been developed and are used by researchers in Education and Psychology. About one hundred and twenty such systems are reported in 'Mirrors for Behaviour' by Simon and Boyer (1970).

There are a number of observation schedules and check lists and other instruments which are developed to study transactions in the laboratory setting. Science laboratory Interaction Category developed by Penick et al. (1979), Q sort instrument developed by Abraham. M. (1982), Classroom Observation Instrument developed by Eggleston et al. (1976) are some of the many instruments developed. They are particularly useful in science laboratories and classrooms to monitor teaching behaviour in order to assess the extent to which the strategies conducive to teaching and learning of science process skills are used.

A purpose of the present study is to obtain an appraisal of the extent to which, in biology practical work, opportunity is provided for the students to use science process skills, since this should be one of the major features of the biology practical classes if the BSCS materials were being used.

In the present study it was decided to adopt one or more existing observation schedules. The instruments developed by Smith (1971) for the Earth Science Curriculum Study and the Observation schedule developed by Eggleston et al. (1976) were judged to be appropriate for present purposes, since both were developed to study teaching and learning strategies used in science classes. These studies were particularly focussed upon the use of the inquiry method of teaching science which requires teachers to provide opportunities for the students to use science process skills. However, it was not appropriate to use these schedules in their entirety on this occasion for the reasons discussed later, and so it was decided to use an eclectic approach and compile a schedule by borrowing relevant parts from each of these two schedules.

5.31. A brief description of the schedules used in the present study

(a) Smith's Schedule relevant to the Earth Science Curriculum Project.

Smith's Schedule is based on the philosophy of the Earth Science Curriculum Project which is an inquiry based curriculum.

It is an elaborate schedule with 94 categories relevant to students' and teacher's behaviour in four classroom phases namely:

- Developing text materials, which is mainly relevant to theory lessons
- Pre-laboratory phase
- Laboratory phase
- Post-laboratory phase

Three types of behaviours are identified and monitored by the schedule namely, behaviours which are consistent with the philosophy of the (ESCP) curriculum, behaviours which are neutral to the philosophy of the curriculum and behaviours which are inconsistent with the philosophy of ESCP.

This schedule is evaluative, descriptive and discriminative and can provide information about the extent to which teaching and learning is process- based or traditional.

In each of the four classroom phases several student and teacher behaviours relevant to that particular phase are monitored. If a behaviour relevant to one classroom phase is observed in a different classroom phase it is not recorded. For instance, if a pre-lab behaviour occurs during a lab- phase it is ignored. If a lab classroom phase is judged by the observer to be changed into a different phase the observer changed what was being monitored and began to observe the categories that were relevant to the new phase of activity. An intensive training is required to use these 94 categories of this observation schedule.

5.32. A brief description of STOS: Science Teaching Observation Schedule by Eggleston, Galton and Jones (1976)

The purpose of STOS was to identify different methods of teaching science and then to investigate a possible relationship between such methods and the products of different teaching methods discerned by the schedule (Eggleston, Galton and Jones (1976) p.1). It was developed for use in both laboratories and theory lessons.

A major purpose of SIOS was to assess the extent to which teaching methods conducive to learning of science process skills are used in science classes.

It is also an evaluative as well as a descriptive instrument. The categories monitor interaction between teachers and students, students and teachers, teachers and materials and students and students. Teachers' categories are grouped under three major headings; teachers' statements; teachers' questions and teachers' directives. Categories relevant to students' behaviour are grouped under two main headings namely pupil seek information and pupils refer to teacher.

It is a sign system which records the occurence of behaviour monitored during an observation period. In the study of science classes in Britain, Eggleston, Galton and Jones (1976) used an observation period of three minutes duration. During any one time period occurence of all behaviours was monitored and recorded so in any one time period any number of the categories could be recorded.

5.33. Observation schedule used in the present study

As part of the present study, an attempt was made to gain some information about the teaching methods used in biology practical classes so as to have some measure of the extent to which teaching methods conducive to learning of science process skills are used, and also to know the degree to which other teaching methods were used which are either inconsistent with the inquiry method or are neutral to inquiry method.

Smith's schedule and STOS were relevant to the present study but not appropriate in their entirety for use in Pakistan. An observation schedule was required which could be applicable in Pakistan and could give some measure of use of science process skills called upon in biology practical work.

A schedule was compiled by borrowing nineteen categories from Smith's schedule and four from STOS (A copy of the observation schedule is given in Appendix 5C). The schedule was tried and developed in a pilot study on video cassettes and a film in the University of Keele.

5.34. The pilot study

The pilot study was carried out in two phases. The first phase was carried out in Keele on three video cassettes and one film. The purpose of this pilot study was to compile a schedule and to develop a consistency in the translation and recording of categories.

During the pilot study the schedule was divided into time units each of two minutes duration. All categories were monitored during one time unit following the methods used by Eggleston et al. (1976).

The results obtained were then analysed to see if the schedule could discriminate between different teaching methods, that is, the teaching methods conducive to learning of science process skills, neutral behaviour and behaviours inconsistent with inquiry method.

Results of observation of video cassettes of two science classes, one taught by a male teacher and the other by a female teacher, were compared to assess the discriminating ability of the schedule. The results are given in Table 5.12.

Table 5.12. Results of the Pilot Study (percentage in brackets)

Categories	Frequency of use of each category Male teacher	Female teacher
Pro-inquiry	327(77)	63(19)
Neutral	100(23)	75(23)
Inconsistent with inquiry	0 (0)	188(58)
Total	427(100)	326(58)

Investigatory indices were calculated for both teacher and an inquiry index of 3.27 was obtained for the male teacher and an investigatory index of .23 was obtained for female teacher.

The investigatory indices were calculated by dividing sum of the inquiry items by that of the anti-inquiry and neutral items, following the method suggested by Tamir (1977).

The two teachers observed were further compared on the use of categories consistent with inquiry method of teaching science. The difference in the mean use of inquiry categories reached a statistical level of significance ($p<0.01$) as tested by the t test. These results established that the schedule was discriminating.

Reliability

The test of interrater reliability was not relevant to this particular study since the schedule was tried and used by one observer only. In order to establish if the observer could translate the behaviours into categories consistently the two observations made at different times on the video cassette of the class conducted by the male teacher were compared and a Pearson's product moment coefficient (γ) was computed. A value of 0.94 was obtained. A record of duration and occurence of Pre-lab, Lab and Post-lab phases was made by drawing a vertical line across the time unit when judged to change into the next phase. For the purpose of the present study three phases were defined as follows:

- Prelab phase: When the teacher and students discuss or teacher describes the problem to be investigated and method of investigation,
- Laboratory phase: A phase when the students perform the experiment and collect their data.
- Post-lab phase: A phase when the analysis and discussion of the results starts.

However, during each phase the occurence of all categories was observed and recorded.

The second phase of pilot study was carried out in a live classroom in Pakistan and as a result the two-minutes time units were extended to four- minutes duration time units as these were manageable and were judged to be adequate for the purpose of the present study.

5.35. Results

Altogether 22 practical lessons were observed in Pakistan. Eight of these were conducted by BSCS-user lecturers and 14 by EPB-user lecturers. The type of practical lessons observed were then grouped under four headings namely: classification, dissection, microscopic work and physiology lessons.

Table 5.13. Number of lessons observed in each type of college

Practical lesson	Number of classes observed		
	BSCS-user college	EPB-user college	Total
Classification	4	2	6
Dissection	1	1	2
Microscopic work	1	6	7
Physiology	2	5	7
Total	8	14	22

The results obtained from the observation of EPB-user and BSCS-user colleges are discussed first to see how much time was being spent on pre-lab, lab and post-lab phases in different practical lessons.

5.35.1. Total time used in each practical lesson

Officially practical lessons are timetabled for 90 minutes duration in each college but the results obtained revealed that there was great variation in the total amount of time used by different lecturers in the two groups.

Table 5.14. Mean duration of practical lessons observed in BSCS-user colleges and EPB-user colleges

Colleges	Classes observed	Mean time (S.D.)
BSCS-users	8	66.00 (± 26.790)
EPB-users	1	72.88 (± 30.910)

5.35.2. Occurence and duration of the three lab-phases in BSCS-user and EPB-user classes

The summary table of results (Table 5.15) shows that in both EPB and BSCS-user colleges approximately one quarter of the time was spent in pre-lab discussion and instructions though within each group there were appreciable variations as is revealed by the values of the standard deviation. In both types of college approximately three quarters of the time was spent on the lab-phase. The difference in mean duration of time used for each laboratory phase was tested for statistical significance. The value of t test obtained did not reach a statistical level of significance. There is no statistically significant difference between the amount of Pre-lab and Lab time spent in practical classes by lecturers in EPB-user colleges and lecturers in BSCS-user colleges.

Table 5.15. Duration of three lab phases in BSCS-user and EPB-user colleges (Time units of four minutes)

Laboratory phase	Time used for each lab phase	
	BSCS-user classes x (± S.D.)	EPB-user classes x (± S.D.)
Pre-lab	25.20 (±29.54)	28.02 (±15.23)
Lab	72.95(±30.32)	69.09 (±15.8)
Post-Lab	1.85	2.87

Post-lab discussions were held in only three individual classes observed, hence the mean duration of the post lab phase is negligible.

5.35.3. Variation between types of practical lessons observed in BSCS- and EPB-user colleges

The results obtained reveal that the amount of time used in Pre-lab phase varies with the type of practical lessons. In BSCS-user colleges Pre-lab phase was considerably longer in Physiology lessons where more than 50% of the total practical time was spent on Pre-lab activities. However, in classification lessons very little time was spent on Pre-lab work. Tamir found similar patterns in his study of practical lessons of biology in High school classes. He found that a relatively longer period of time was devoted to the Pre-lab phases in practical lessons which may be characterised as 'experimental' than in those which may be characterized as 'descriptive' (Tamir 1977)). He considers Physiology lessons as experimental type lessons.

In neither of these type of lesson were lecturers in BSCS-user colleges observed to be engaged in any Post-lab work though it does happen on occasions, as seen by the fact that it occured in the one laboratory lesson on microscopic work that was observed in such college when it lasted for 14.81 minutes.

In EPB-user colleges most Pre-lab time was spent in classification lessons though in all kinds of lessons observed lecturers spent an appreciable amount of time on Pre-lab work (mean time varies from 18.95 to 56.50 minutes as compared to 0.00 to 58.5 minutes in BSCS-user colleges).

Very little, if any, time was spent in Post-lab activity in EPB-user colleges; the mean time devoted to Post-lab activities there ranges from 0.00 to 4.28 minutes.

The difference in the pattern for classification classes and for physiology classes between EPB-user and BSCS-user colleges suggests the lecturers differ in their approach to practical work.

However, Post-lab discussions, characterise the inquiry approach to teaching science (Raghubir (1979), Tamir (1977) Smith (1971). Findings of the study of practical lessons of biology in Israel suggest that an inquiry-oriented laboratory leads to a post-lab discussions which was required in order to draw meaningful conclusions and to relate them to an appropriate conceptual framework (Tamir (1977) p.313). In the present study there is little evidence of it in either BSCS-user or EPB-user colleges.

Furthermore, Pre-lab is also a feature of the inquiry approach provided it is devoted to identification of the problem and method of investigation with the assistance of the teacher without revealing results and conclusions (Raghubir (1979)). Pre-lab is witnessed in the practical classes observed, but to very different degrees between one kind of practical class and another and also between the two types of college. There is no evidence, however, that lecturers in BSCS-user colleges, that is, lecturers using books which accentuate the process approach to science teaching spend more time on pre-lab work than do lecturers in EPB-user colleges who are using text books that are far more traditional and expository in their approach to science teaching.

5.35.4. Frequency of occurence of pro-inquiry, neutral and anti-inquiry categories of lecturers' activities

Observation in practical lessons were also kept of the incidence of pro-inquiry, neutral and inconsistent with inquiry (referred to for convenience as anti-inquiry, hereforth) activities by lecturers, as defined by Smith (1971) and discussed earlier. The occurence of these categories in four types of Biology practical lessons taken by lecturers in BSCS-user colleges and by lecturers in EPB-user college is summarised in Table 5.16.

Table 5.16. Percentage of pro-inquiry, neutral and anti-inquiry categories engaged in by EPB-users and BSCS-users

	Classification lessons in		Physiology lessons in		Microscope lessons in		Dissection lessons in	
	BSCS	EPB	BSCS	EPB	BSCS	EPB	BSCS	EPB
Pro-inquiry	22.9	0.00	12.3	09.9	13.5	16.5	19.7	09.3
Neutral	39.5	28.9	30.0	23.2	50.8	24.2	37.9	37.2
Anti-inquiry	37.6	71.1	57.7	06.9	35.6	59.7	42.4	53.4

The lecturers' behaviour was monitored such that in each time unit it could be classified into any or all of the three categories under discussion, namely pro-inquiry, neutral to inquiry or anti-inquiry. The number of time units in which each kind of behaviour was observed was counted and the total established. From this total the percentage time devoted to each category is calculated.

This percentage (see table 5.16) gives the proportion of the practical time devoted to pro-inquiry, neutral and anti-inquiry activities. The results shows that in both types of colleges least time is spent on pro-inquiry activity. However, in three out of four types of lessons observed, lecturers from the BSCS-user colleges spent more time in pro-inquiry activity than did EPB-user lecturers. The exception is the microscope lesson.

In both BSCS-user classes and in EPB-user classes pro-inquiry activity was observed only for a minority of time. The proportion of time in which pro-inquiry activity was witnessed ranged from 12.3% to 22.9% in BSCS-user classes and from 0% to 16.1% in EPB-user classes. In all cases EPB-user lecturers spent more time on anti-inquiry activity than did BSCS-user lecturers.

Some pro-inquiry activity did occur in BSCS-user and in EPB-user colleges and there are signs of it being more in evidence in BSCS-user colleges than in EPB-user colleges. In all cases and in both types of college however, more time was spent on behaviour inconsistent with inquiry than was spent on behaviour consistent with it.

5.36. Categories of behaviour displayed by teachers and students

In the present study each of the 23 categories in the schedule are monitored in each time unit, so in any one time unit any number of categories could be recorded. However, in any time unit only the first occurence of each category is counted and so the results discussed here give the minimum use of each category by the lecturers and the students in a practical lesson.

For each practical lesson the number of time units in which each category occured during a practical lesson is added. Since the duration of the various practical lessons differed a percentage of time units in which each category was recorded has been calculated for each lesson so as to make the results comparable.

5.36.1. The results

Nineteen categories of the schedule monitored teachers' behaviour and four categories monitored students' behaviour. Out of the 19 teachers' categories nine were pro-inquiry categories, four were neutral to inquiry categories and six were anti-inquiry categories. Out of 4 students categories 2 were pro-inquiry categories and 2 were neutral categories.

The results are discussed taking teachers' and students' behaviour separately.

5.36.2. Use of categories by the lecturers in different lessons.

A summary of the use of pro-inquiry categories, which includes seven questions and two statements is given in Table 5.17. The results indicate that, in both EPB-user and BSCS-user classes, lecturers made only negligible use of pro-inquiry categories. The only pro-inquiry category used was ‘teachers questions asking students to observe an object or phenomena’.

In EPB user classes in microscopic work and classification, this category was observed in more time units than in physiology classes, while, unexpectedly, in classification lessons even this category was not used by the lecturers.

In BSCS-user colleges this particular pro-inquiry category was most often observed in classification lessons while in each of other kinds of lesson it was used to a similar extent. The results indicate that lecturers in BSCS-user classes ask questions that require students to make observations more frequently than do the lecturers in EPB-user colleges.

However, there is no evidence that the lecturers give attention to science process skills other than to the skills of observation since all other pro-inquiry categories in the schedule were either never used or only very rarely used. These results reinforce the finding that the lecturers value the skill of observation in both their perceptions and practices, and they give comparatively little attention to other science process skills.

Results have shown that anti-inquiry categories and neutral categories are used more frequently than pro-inquiry categories by lecturers both in BSCS-user and EPB-user colleges

A summary of each anti-inquiry category used in BSCS and EPB colleges is given in Table 5.18.

In EPB user colleges and in four types of lessons observed the pattern of use categories varies from lesson to lesson.

For instance, in microscopic work and in physiology, statements of procedures were made more often than were any other statements. In classification lessons surprisingly, factual statements were made in most of the time units and statements of procedures were made in fewer times units than were other statements. There seem to be no set pattern, and style varies from one type of lesson to the other.

In BSCS-user colleges, also, the pattern of use of statements varies from one type of lesson to the other.

In classification and physiology lessons more emphasis is given to factual information than to procedures and observations. In dissections and microscopic work more emphasis is given to observation since the statements describing observations to be made were recorded most often.

Comparison of classes of BSCS-user and EPB-user lecturers reveals that, in classification lessons and dissections, both groups use much the same approach. In classification more statements of fact and procedure were recorded than other statements.

Table 5.17 Mean use of Pro-inquiry categories in BSCS and EPB (Percentage time used in minutes)

Category	Lessons observed							
	Classification		Dissection		Microscope		Physiology	
	EPB n=2	BSCS n=4	EPB n=1	BSCS n=1	EPB n=6	BSCS n=1	EPB n=5	BSCS n=2
Teacher Asks to								
Observe	0	42	27	32	29.17	37	12.8	37.5
Organise data	0	8.5	0	0	0	0	0	10.0
Compare results	0	0	0	0	0	0	0	0
Make hypothesis	0	0	0	0	0	0	0	10.0
Identify source of error	0	0	0	0	0	0	0	0
Predict the results	0	0	0	0	0	0	0	0
Suggest procedures	0	0	0	0	0	0	0	5.0
Teacher makes statements of								
Safety precautions	0	0	0	0	1.5	0	0	0
Probable difficulty in investigation	0	0	0	0	1.7	0	3.0	0

Table 5.18: Mean use of anti-inquiry categories in BSCS User and EPB User Classes (Percentage time used in minutes)

Category	Lessons Observed							
	Classification		Dissection		Microscope		Physiology	
	EPB n=2	BSCS n=4	EPB n=1	BSCS n=1	EPB n=6	BSCS n=1	EPB n=5	BSCS n=2
Teacher Makes Statements of:								
Facts	66.00	29.25	36	45	27.00	35.00	24.6	46.5
Procedures to be used	11.81	23.20	55	64	34.50	30.00	36.2	45.0
Conclusions to be drawn	3.89	0.00	0	0	2.83	3.00	8.2	17.5
Observations to be made	25.69	24.10	59	55	33.50	37.00	12.6	31.5
Teacher								
Ignores Students questions	0.00	0.00	0	0	7.50	0.00	0.00	0.00
Leaves the classroom	12.30	5.00	0	18	7.50	3.00	49.6	5.00

n = number of lessons observed

In both EPB-user colleges and BSCS-user colleges in comparatively few time units statements of 'descriptions of observations which students should make' were recorded in physiology lessons. More attention was given either to procedures (in EPB-user classes) or to facts (in BSCS-user classes).

Except for one class, students' questions were always answered fully and factually. The lecturers rarely left the classroom.

The results suggest that in practical work in biology and in both EPB- user and BSCS-user colleges, the lecturers' main concern is with observation, procedure, or fact and inquiry skills, other than observation are not given attention.

The neutral category was also quite frequently used in both BSCS-user and in EPB-user classes. In EPB-user colleges in classification, dissection and physiology lessons, lecturers more often perform the tasks in order to tell the student the method to be used. Teachers' questions asking students to describe an object or phenomena were more frequent in microscope lessons than in other lessons.

Teachers in EPB colleges often gave direct answers to students questions, with students asking more questions in dissections and with microscope work than in classification and physiology lessons. However, lecturers' questions, asking students, 'to describe an object or phenomena' were very rare.

In BSCS-user classes, also, lecturers do demonstrations to tell students the procedure of experiment and more frequently in physiology and dissection lessons than in classification and

scope-work lessons.

As in EPB-user colleges more questions were asked by the students, and directions given by the lecturers in dissection and physiology lessons than in microscope work.

Lecturers' questions relevant to the description of an object or phenomena were more frequent in classification lessons and to some degree in physiology lessons, but these questions were asked very infrequently during microscope work or dissection.

The use of neutral categories varied greatly from one lesson to the other but here again the lecturers' main emphasis seem to be on the procedures of the experiment, since there were either demonstrations of methods or experiments or answers to students' questions about the methods of experiments.

Questions requiring students to describe why or how a phenomena occured were in rare both EPB-user and BSCS-user classes.

These results indicate that in biology practical lecturers mainly attended to observations, or procedures, or factual knowledge; process skills and also questions requiring students to describe and to give reasons for something were rarely attended.

Keeping in view the limitation of the schedule used in this study, it can be concluded that the science process skills monitored are not given emphasis in practicals and this is the case in both BSCS-user colleges and in EPB-user colleges.

Using the method suggested by Tamir (1977), investigatory indices were calculated for each lecturer (see Table 5.19).

These results indicate that just one of the 22 lecturers observed used 'pro-inquiry', 'anti-inquiry' and 'neutral to inquiry' categories equally (Lecturer B1). In all other cases the investigatory indices show high use of categories other than pro-inquiry categories.

There is no evidence that lecturers are giving attention to the process skills in their practicals. This finding is consonance with the evidence concerning the the perceptions of the lecturers which indicate that practical work is perceived as catering mainly for content and manipulative skills. Skill of observation, which is a process skill, is given attention both in perceptions and practices, but very few other process skills occur either in their perceptions or in their practices.

Table 5. 19: Investigatory indices of EPB and BSCS-users

Lecturers	Classification	Dissection	Microscope	Physiology
EPB-users				
E1	0.01			
E2	0.00			
E3		0.11		
E4			0.13	
E5			0.17	
E6			0.23	
E7			0.29	
E8			0.09	
E9			0.18	
E10				0.07
E11				0.06
E12				0.18
E13				0.11
E14				0.09
BSCS-users				
B1	1.00			
B2	0.22			
B3	0.19			
B4	0.20			
B5		0.14		
B6			0.26	
B7				0.35
B8				0.10

* The index is calculated by dividing the total number of pro-inquiry categories by total categories.

5.36.3. Students' activities in biology practical lessons

The results of students' activities need to be treated with caution since only four students behaviours could be monitored in this study. It gives no more than a small measure of the activities of the students.

In both EPB-user and BSCS-user colleges students made observations, which reflect that students are involved in doing experiments and, whether fully directed by the teachers or partially, they do manipulate equipment and handle materials. However, very rarely did students refer to teacher to make an inference.

In classification lessons students questions were most often relevant to confirmation of a fact and in both EPB-user and BSCS-user colleges. In dissections both in EPB and BSCS classes students' questions were more often relevant to the method than to the factual knowledge.

Similarly, in microscope work and in physiology, and again in both EPB-user and BSCS-user colleges students questions were directed more towards the method than toward seeking knowledge of facts of making inference.

So there are some indications that students' accent is on procedures and factual knowledge and just as in the lecturers' case, there is a consistency in students' views and practices. Students value their practical work more for learning content, developing skills of observation and manipulative skills and in their practices they give more attention to learning facts than to process skills.

Table 5.20 Student activities in different classes (percentage figures)

Categories of Students activity	Lessons Observed							
	Classification		Dissection		Microscope		Physiology	
	EPB n=2	BSCS n=4	EPB n=1	BSCS n=1	EPB n=6	BSCS n=1	EPB n=5	BSCS n=2
Make observations	47.5	88.50	27	64	49.00	27.0	35.17	22.5
Refer to teacher to make inference	0.0	6.50	09	0	7.67	7.0	7.00	13.5
Ask teacher to help with experiment	5.0	16.25	54	68	25.17	11.0	21.00	12.6
Seek or confirm a fact	28.5	49.25	10	22	26.33	11.0	15.00	4.0

5.40. The effect of examination on curriculum

Examinations are an essential part of a course of study and not something divorced from it. The curriculum seems to have four dimensions: the aims and objectives dimension; the subject matter dimension; the activity dimension and the assessment dimension. The fourth should match with the other three both qualitatively and quantitatively (Mathews and Leece (1976)).

Matys (1970) succinctly describes the relationship between curriculum and examinations as follows:

> "examination and curriculum are two sides of the same coin and it is only when they operate together that the goals and objectives of education are reached"
> (Matys (1970)p.13)

Examinations affect the curriculum in two respects;

(i) the content and orientation of curriculum in various subject areas taught.

(ii) the techniques, styles and strategies adopted by teacher (Kempa (1986)).

In an evaluation of a curriculum it is important to make sure that the examinations that are used (a) reflect the same goals and (b) promote the same spirit, objectives, emphasis and priorities that the curriculum planners had in mind (Matys (1970)).

Studying the effects of innovations on examination or vice versa is considered to be an important area of investigation for a comprehensive contextual evaluation (West (1975)), Lewy (1977)).

Unfortunately, at secondary and higher secondary level, examinations are so important in society that most teachers, faced as they often are with choosing between education and opportunity for a substantial proportion of their pupils to pass, opt for the latter. Their aim is to get their pupils through the examination (Stenhouse (1975)).

In recent developments in Britain and in America more recognition is being given to the effect of examinations in curriculum implementation. The new patterns and methods of assessment, the shift from norm-referenced to criterion-referenced testing and the setting of detailed criteria of assessment all point to the fact that the examination is considered to be a key factor in the implementation of innovations.

The importance given to the study of the interaction between the examination and the curriculum in the literature (Kempa (1986), Matys (1970), Mathews and Leece (1976) and Eggleston (1973)) and the finding that the lecturers of biology in Pakistan give high priority to examinations, calls for a brief appraisal of examiners' and paper setters views as to what do they see is assessed in practical examinations and how the pattern of the examination fits into the aspirations of policy makers and lecturers priorities and practices.

Intermediate stage is an important turning point in the educational life of students in Pakistan. It is from this stage that they are channelled in different directions. Some succeed in getting admission to professional degree courses (mainly engineering and medicine), some opt for general degree courses and for others it is the terminal stage as they leave the system after Intermediate. Entry into degree courses (professional and general degree course alike) depends on students marks in external examinations set by the Board of Intermediate and Secondary Education. The merit required for entry into professional degree courses is higher than for general degree course. Those who wish to join medicine or engineering courses have to have A and A plus grades in Intermediate examinations.

Students who opt for biology at the Intermediate stage are mostly those who wish to join medicine after it. In a sample of 279 students in the present study virtually every student wants to be a doctor. This in itself reveals the reasons why the aim 'to help pass examination' is given priority over many other aims by the lecturers of biology.

5.41. The results

The data were gathered from paper setters and examiners of practical work in Biology at the Intermediate stage. Semi-structured interviews were held with a sample (6) of the paper setters and with a sample (8) of the examiners. These represent an opportunity sample in both cases. The examiners were biology lecturers teaching Intermediate classes. The lecturers of Biology are appointed as external examiners by the Examination Boards to examine practical work in the colleges other than those in which they teach.

The paper setters are usually biology teachers teaching graduate and post-graduate classes.

During the interviews the following questions were asked of the paper setters and examiners.

(1) What criteria do you use to select an experiment for an examination (This question was asked to paper setters only)?
(2) What are your criteria of the assessment of the tasks set in practical examination?
(3) On what bases do you select questions for paper and pencil objective-type questions?
(4) What is/are the purpose(s) of objective type paper - and pencil - tests. What does it assess?

The paper setters are given by the Examination Board an outline of the syllabus along with instructions for the time allocation of the examination. The total time allocated to practical examination is three hours. The practical examination in biology consists of two parts. In part one, objective-type (paper-and-pencil) questions are given and the student has one hour in which to answer these questions.

In the second part of the practical examination students are required to perform different tasks.

Information was sought about the paper setters' methods of selection of tasks and for the criteria of assessment by asking each paper setter to indicate the bases on which he/she selects or samples the objective-type questions and the experiment for assessment. All the setters independently indicated much the same bases for their choices and decisions and these which mainly include following:

(1) The experiments which could be completed within the three-hour examination.

- The experiment for which materials and equipment is available in all colleges.
- The experiments which are not new for the candidates and which they have performed at least once during their studies.

(2) The objective type question for the paper-and-pencil test are selected with a view to:

(a) giving equal weighting to botany and zoology topics ;
(b) giving maximum coverage to the practical syllabus which is not possible by giving a practical test only.

The paper setters did not mention any science process skills in their criteria.

The paper setters were further asked to indicate the criteria they set for assessment of different tasks. In practical examinations candidates are required to:

(a) set up apparatus to demonstrate an experiment and write and /or describe the method, the process, the equipment and the results or fully perform the experiment, that is to collect data and write up their results.
(b) dissect an animal draw and label its organs or system.
(c) prepare a temporary slide of given materials and identify the specimen to required level of classification; draw and label the diagram with accurate spellings.
(d) Classify an animal or plant using classification key.

These are the types of activities which are usually included in assessment. They belong to four major areas of practical work in biology namely, physiology experiments; dissections; microscopic work; classification.

TABLE 5.21: Criteria for Assessments in Practical Work: Paper-Setters Views.

Area	Criteria of Assessment	No. of Paper setters n = 6
Physiology	(a) Ability to describe the phenomena.	3
	(b) Ability to set apparatus.	6
	(c) Ability to perform experiment carefully, methodically and neatly.	6
	(d) Ability to select appropriate apparatus and materials.	3
	(e) Ability to make accurate observations.	3
	(f) Ability to interpret observations.	3
	(g) Ability to draw neat and accurate diagram.	3
Classification	(a) Ability to make accurate observations.	6
	(b) Ability to find similarities and differences in organisms.	6
	(c) Ability to give correct name of specimen with correct spellings.	6
Dissections	(a) Ability to handle the animal.	4
	(b) Ability to dissect the animal with swift hand.	4
	(c) Ability to expose the organs and systems without mess.	6
	(d) Ability to recognise the organs.	6
	(e) Ability to draw correct diagram.	6
Microscope Work	(a) Ability to prepare a temporary slide.	6
	(b) Ability to identify the specimen.	6
	(c) Ability to give correct name of specimen with correct spellings.	6

Each task involves a range of science process skills. In order to find out which process skills, if any, are assessed, the paper setters were asked to indicate the criteria they set for assessment of each task. Their responses are given in the Table 5.21.

The results obtained reveal that the criteria of assessment mentioned by the paper setters are predominantly based on the assessment of manipulative skills and on some knowledge and memory. Very few science process skills are included/mentioned as criteria of assessment. In fact, it is mainly the observation skill which is assessed and to some degree the skill of communication and interpretation of the results is assessed.

One third of the total examination time (that is, one hour) is allocated to the objective-type paper and pencil test. In order to find out to what extent process skills are assessed in this paper and pencil objective-type test the paper setters were asked to indicate the bases of their selection of these questions and the abilities they assess, or wish to assess through this test. They replied saying that the bases of selection of questions for objective type paper were maximum coverage of the practical course and equal weighting to botany and zoology topics. No other bases of selection were mentioned by any other paper setter.
The abilities which are assessed in this part of the examination according to paper setters are given in Table 5.22.

Table 5.22. Criteria of assessment in paper-and-pencil test. Paper setters' responses.

Criteria of assessment	No of paper setters n = 6
Student's knowledge and grasp of the subject	3
How thorough is the student in his/her study of the subject	3
Students' knowledge of experiments (the procedure, apparatus, results) not included in the practical test	1
Students' intelligence and ability of quick response	1
Students' ability to rote learn the facts and principles	1

These results indicate that there are no set criteria of assessment of practical work. It is also apparent that the paper setters who were included in this study do not include science process skills in the objective type test. Objective type test, as is revealed from these results, is limited to the assessment of knowledge and memory.

However, precisely what is assessed in practical examinations depends to a great degree on the external examiners. Their views are given in the following section.

5.42. Criteria of assessment used in practical examinations

Some of the lecturers of biology currently teaching Intermediate classes are appointed as the external examiners for practical examinations at the Intermediate stage.

Most of the lecturers who were interviewed had the experience of being external examiners and marking students work in the public examination.

Lecturers, without exception, showed little interest in the issue of assessment in practical examination. More than 50% of the lecturers interviewed were of the opinion that practical examination at the Intermediate stage is at least a mere formality and the 50 marks available for the practical examination are simply bonus marks for all students. Virtually all the lecturers seriously maintained that the criteria for giving marks is so lenient that very rarely a student fails in practical examination.

The lecturers expressed dissatisfaction with the examining of the practical component of biology at Intermediate stage. Some felt so strongly that they have stopped taking the duty.

Only eight lecturers of the 65 talked about the issue of assessment in detail and gave constructive views and opinions. However, they said that the present practical examination is given very little importance by the academic staff either in teaching or in their examining. These 8 also referred to use of unfair practices in the system.

Lecturers pointed out that the syllabus includes a number of lengthy experiments which could not be given in the practical examination since this was only of 3 hours duration. The general view was that the practical examination, in its present form is not a fair one and a number of lecturers felt that continuous assessment throughout the year would be preferable.

The examiners were asked to name the criteria by which they mark the students' work done in the practical examination. The responses are given in Table 5.23.

The criteria of assessment most often named by the external examiners indicate that the abilities which are assessed are predominantly those of manipulative skills and knowledge of the subject. Science process skills other than observation are rarely mentioned as a criterion of assessment.

When examiners did mention some process skills they ruefully added that it is very rare for these abilities to be assessed. 'I try to assess these abilities, one examiner said, 'but it is not possible since no one teaches these things'.

There is less consistency in criteria of assessment used by the examiners, as judged by their replies, to the request to indicate their views about the abilities which are assessed in objective-type questions' test. (See Table 5.24)

Table 5.23: Criteria of Assessment in Practical Examinations; Examiners' Views.

Experiment	Criteria used in assessment	No. of Examiners (n=8)
Physiology	1. Knowledge of subject under study	5
	2. Ability to handle apparatus	8
	3. Ability to make observations	3
	4. Ability to perform experiment methodically, cleanly.	8
	5. Ability to understand different aspects of experiment for instance:-	
	(a) Purpose of Control	1
	(b) Identification of Control	1
	(c) Identification of Hypothesis	1
Classification	(a) Knowledge of terms	7
	(b) Knowledge of characteristics of organisms	8
	(c) Ability to make observations	1
Dissections	(a) Knowledge of structures of animals	7
	(b) Ability to handle the animal	8
	(c) Neat and clean dissections	8
	(d) Ability to expose organs and systems fully	8
	(e) Ability to make accurate observations	1
Microscope Work	(a) Students knowledge of name with accurate spellings	5
	(b) Ability to draw specimen accurately	7
	(c) Ability to make accurate observations	8
	(d) Ability to memorise names and other details	7

Table 5.24. Abilities assessed in paper and pencil test: examiners' views

Abilities assessed	No of examiners (n=8)
(1) Knowledge of the subject	8
(2) Assessment of students' intelligence	4
(3) Understanding of experiment	1
(4) Ability to memorise facts	4
(5) Ability to identify control	1
(6) Ability to identify hypothesis	1
(7) Ability to interpret	1

These replies indicate that the paper-and-pencil test is mainly taken as assessing knowledge and the ability to recall facts and principles even though it is part of the practical examination. Only one examiner mentioned some science process skills saying that it was very occasionally that questions which assess these abilities are added in the objective- type paper. The practical work at Intermediate stage is assessed but there is no evidence of much attention being given in the assessment to science skills other than the skills of observation.

5.50. The laboratory facilities

The introduction of new curricula often requires changes in existing facilities in order to enable the students and the teachers to use new materials and methods. In the science curricula of the 1960s laboratories were given a key role in learning and teaching science. As Hurd (1964), in his discussion about the organisation of BSCS (Biology Science Curriculum Study) laboratories has commented, 'it is very unlikely that traditional biology laboratory facilities will be entirely adequate for modern courses', and so indicated the need for provision of new laboratory facilities.

During the preliminary survey in Pakistan in the present study lecturers of biology who were teaching Intermediate classes were found to be critical of the existing laboratory facilities for teaching the Intermediate biology course. Limited laboratory facilities, in terms of services and equipment are, in the lecturers' view a major constraint on full implementation of the biology practical syllabus.

These remarks by lecturers were followed up and a biology laboratory inventory was administered in order to monitor a number of the aspects of laboratory facilities that lecturers raised as constraints and that were judged to be important in this context, such as the provision of services and equipment and the degree of overcrowding of laboratories and the student teacher ratio. The laboratory inventory used is given in full in Appendix 5E.

The laboratory inventory was administered in 22 colleges which include 16 EPB-user colleges (10 of them Degree, and 6 of them Intermediate colleges) and 6 BSCS-user colleges (5 Degree, and 1 Intermediate college). The laboratory inventory was administered by the researcher and the data collected by observation and from college records.

The purpose of the laboratory inventory was to study the degree to which in Biology practical sessions, classes are overcrowded, the student-teacher ratio and the extent to which laboratory facilities are limited. These were said to be the factors which put a constraint on carrying out the practical work as required by the curriculum.

5.51. Intensity of use of biology laboratories by Intermediate classes

The number of biology laboratories available for Intermediate classes in relation to the amount of time available to use these laboratories could effect the full implementation of practical component of biology curriculum.

In the present study a ratio in each college of the number of biology laboratories available to a theoretical maximum possible time available to use these laboratories for the Intermediate biology classes was estimated, to determine the degree of use of biology laboratories per week for such classes.

In order to estimate the proportion of the time biology laboratories are used by the Intermediate classes a theoretical maximum possible laboratory period hereafter called ‘laboratory unit’ was estimated. The theoretical maximum possible lab units available for each college is estimated on the assumption that on any one working day at the most three practical lessons each of 90 minutes duration could be held. On the basis of this assumption, in a full week (of 6 working days) 18 practical lessons can be held in any one laboratory provided it is set aside entirely for Intermediate classes. Taking 18 as the maximum possible lab units available for Intermediate classes an estimate was then made of the actual laboratory units which are used by Intermediate classes.

In order to estimate the use of Intermediate classes the maximum possible units were adjusted according to the laboratories made available wholly or in part for the Intermediate biology classes. For instance, in a college with one biology laboratory available for both B.Sc. and Intermediate students nine maximum possible laboratory units can be used for Intermediate classes. If a college has two biology laboratories available for Intermediate biology classes the maximum possible units are doubled and the college will have 36 maximum possible laboratory units.

Using the 18 units as the maximum possible laboratory units and adjusting it to the number of laboratories available for Intermediate colleges, the number of laboratory units used by each college was determined and the relationship between the two taken to be a measure of the intensity of use of biology laboratories.

The results are given in the Table 5.25 and 5.26.

The results obtained from the two types of college reveal that in all BSCS—user Degree colleges included in the study the laboratories are in use for more than 50% of the available units of time. In comparison to the three out of ten EPB-user Degree colleges have the laboratories used to this intensity. In the rest of the EPB-user Degree colleges the laboratory units are in use for less than 50% of the maximum possible available units of time.

In five out of six EPB Intermediate colleges the laboratory units used are less than 41% of the total available units. In fact only one EPB-user Intermediate college used more than 50% of the maximum possible laboratory units.

The results indicate that in the BSCS-user Degree colleges laboratories are used more heavily than in most of the EPB-user Degree colleges and in EPB- user Intermediate colleges the laboratories are used even less heavily than in either EPB-user Degree colleges or BSCS-user Degree colleges. However, there is no evidence to suggest that biology laboratories are too heavily used, and with few of them used for more than half of the available time in the week, it would seem there is no evidence that availability of laboratories is the constraint that at least some lecturers claim it to be.

5.52. Degree of crowding in laboratories in EPB-user and BSCS-user colleges

In inquiry-based laboratory investigations students are often required to perform experiments and to collect their own data. This means that in classrooms where inquiry methods of teaching is used more space per student is required than in the classrooms where the lecture-demonstration method is used (Hurd (1964)).

In the present study a ratio in each biology laboratory of proper sitting places to the number of students working in it at any one time was calculated to estimate whether or not the laboratories were overcrowded. This ratio was calculated for each of the 22 colleges for both first and second year Intermediate biology classes separately. For this purpose in each laboratory the number of sitting places was counted and compared with the number of students working in it any one time.

The laboratories were classified into three categories namely, A, B and C category. Sitting place in this study refers to the working area which can be adequately used by only one student if he/she had to perform an experiment.

- laboratories in which the number of sitting places was equal or more than the number of students were classified as category A laboratories.
- Laboratories in which the number of sitting places in only 1-5 seats less than the number of students were classified as category B laboratories.
- Laboratories in which the number of sitting places was as small as half or even less than half of the number of student working in it were classified as category C laboratories.

The results obtained from the laboratory inventory reveal that there is evidence of overcrowding in biology laboratories of Intermediate classes. Twenty five out of a 44 laboratory classes were found to be overcrowded while only 16 out of 44 had sufficient sitting places.

Overcrowding occurs to a similar extent in both Intermediate-college and Degree-college laboratories. Eight out of 14 Intermediate-college laboratories and 17 out of 30 Degree-college laboratories are overcrowded.

There is some evidence of overcrowding being most common in EPB-user Degree colleges. However, it should be noted that the one BSCS-user college included in the present study had the most overcrowded laboratory. In this college the laboratory was a narrow curved corridor which was used both as a lecture room and as a laboratory. It would have properly housed only 4 people but it held classes of 20 and 30 students, with the overspill going out into a nearby tent.

The results obtained given in the Table 5.25 and 5.26. In EPB-user Degree colleges in the first-year classes (in 3 out of 10 colleges) and from the second-year classes (in 2 out of 10 colleges) are categorised as A category class that is classes which are not crowded. In 7 out of 10 of these colleges both first year and second year classes are overcrowded, with two or sometimes more students squeezed in one sitting place.

In BSCS-user colleges four out of the five Degree colleges have classes not overcrowded. In EPB Intermediate colleges (Table 5.26) in two out of the six have laboratories overcrowded with students and stools. In the BSCS Intermediate college the laboratory was one of the most overcrowded. It was the narrow curved corridor converted into a laboratory and was also used as a lecture room.

The EPB-user Degree colleges were found to be mostly overcrowded and so were the EPB-user Intermediate colleges. In only a few BSCS-user Degree colleges were practical classes overcrowded.

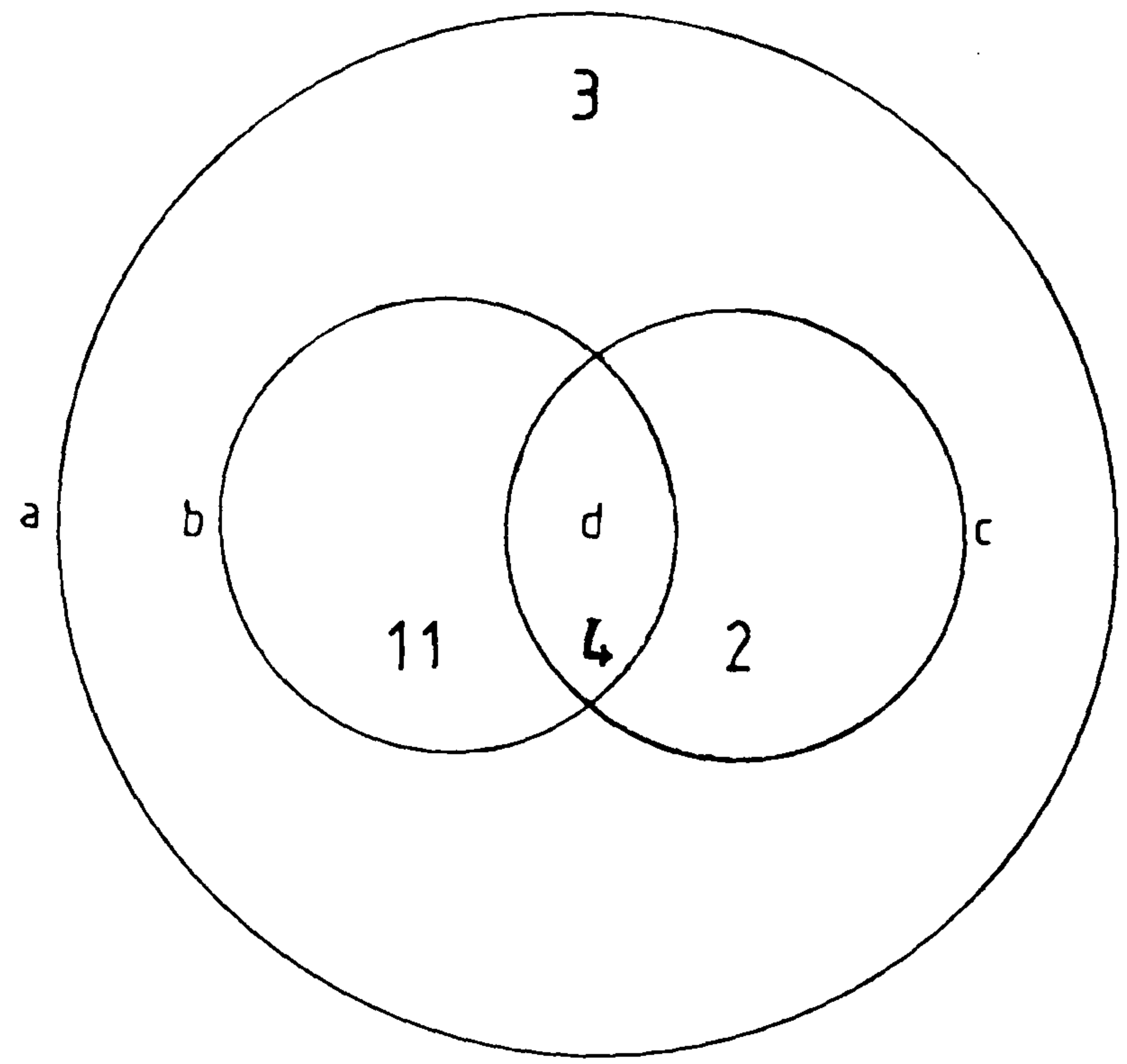
Summary

From the result of the laboratory inventory no evidence is found to suggest that biology laboratories are excessively used by either of the two types of the college surveyed. However, there is evidence of overcrowding in laboratory classes in both BSCS and EPB-user colleges, though perhaps more commonly amongst the latter.

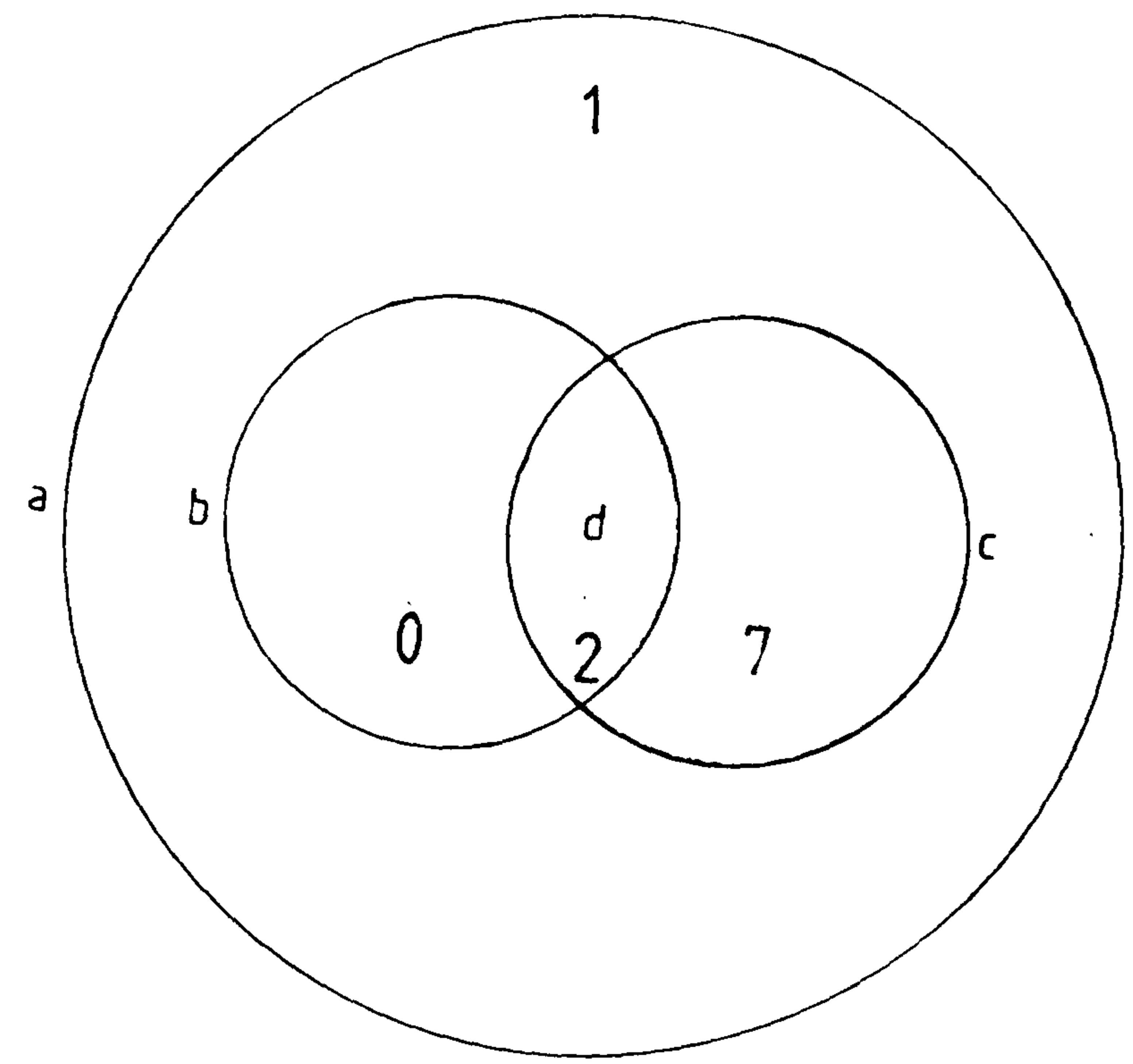
From the venn diagram it can be seen that some EPB-user Degree colleges have laboratories both extensively used and overcrowded, but a number of laboratories in these colleges are overcrowded (11 out of

Venn diagram

Intensity of use of laboratories
and
crowding in the biology laboratories



EPB Degree colleges



BSCS Degree colleges

Key: a = Less than 50% units are used
b = Overcrowded
c = More than 50% units are used
d = More than 50% units are used and overcrowded

20) but not extensively used, suggesting that crowded laboratories are rather a matter of choice, though constraints in addition to those of space might be operating.

In BSCS-user colleges the situation appears to be different in that both colleges that had overcrowded laboratories also had the laboratories in extensive use, which does suggest a shortage of laboratory space for their Intermediate classes.

There is no evidence to suggest that BSCS-user colleges are running practical classes with an accent on process approach for that would be expected, from what is found in the literature, to have no over crowding at all in the laboratories.

5.53. Laboratory services and facilities

Biology laboratories usually have laboratory assistants and attendants to help the lecturers maintain them. Laboratory assistants prepare the materials and are responsible for providing equipment and materials to the students. They arrange the laboratory before the practical period and clear up the laboratory, wash and clean the apparatus after each laboratory session.

According to the laboratory inventory prepared by Novak and Abraham (1964), for a group of 28 to 30 students, one laboratory assistant and one laboratory attendant are considered adequate.

The data obtained in this study reveals that in Pakistan both in BSCS and EPB-user colleges in most of the cases one laboratory attendant and one laboratory assistant are shared between two, and in some cases three, laboratories (see Appendix 5F). There is then a shortage of laboratory services and this could be a limiting factor in the full use of BSCS practical materials, particularly in running those inquiry lessons which are lengthy and require attendants and assistants to look after the apparatus and or animals.

5.54. The equipment

In the present study it was not feasible to run a full check on equipment and so the equipment which was monitored was the number of microscopes (compound and binocular) and the major equipment namely, refrigerator, oven, incubator, pressure cookers, and centrifuge.

In the laboratory inventory prepared by Novak and Abraham (1964) a point system is used. The laboratories are given scores according to the ratio of students per microscope. A laboratory in which one microscope is shared between seven students is given a minimum score of 4 points while to a laboratory in which 4 students share one microscope a maximum score of 8 is given.

The ratio of students to compound microscopes was calculated for both BSCS and EPB-user college laboratories. The results show that in every college 3 to 5 students need to share one microscope which according to Novak and Abraham is adequate with respect to microscopes. The lecturers' complaints about the shortage of compound microscopes are not justifiable in the light of these findings. Binocular microscopes, however, are in severe shortage. In EPB-user colleges of percent of the laboratories either do not have any for Intermediate students or have one for 30 and sometimes 65 students. In BSCS-user colleges six students share one binocular which considering the BSCS- inventory is rather a poor provision. In the only BSCS-user Intermediate college included in this part of the study the number of binocular microscope is one per ten students for first-year classes and one per fifteen students in the second year classes.

A record of the presence or absence of major equipment namely: refrigerators, ovens, incubators, autoclaves and pressure cookers was made (see Table 5.27).

Table 5.27. Percentage of laboratories having major equipment in BSCS-user and EPB-user colleges

Equipment	BSCS-user colleges	EPB-user colleges
Refrigerator	83.33	37.50
Oven	83.33	81.25
Pressure cooker	83.33	50.00
Autoclave	50.00	25.00
Incubator	83.33	31.25

The laboratory assistant helps the lecturer to prepare materials and equipment required for the investigations. The laboratory assistant is also responsible for keeping the stock and providing the materials and equipment to the students.

Table 5.27 reveals that most of the BSCS-user colleges have three major installations while, with the exception of ovens, most of the EPB-user colleges do not. According to these findings it appears that complaints of EPB-user college lecturers for not being able to conduct experiments involving this equipment are to some degree justifiable.

A further appraisal of additional equipment, not monitored by the inventory, but recorded from personal observation and by gathering information from the lecturers, shows that some of the colleges are otherwise well-equiped. A list of the extra installations is given below.

Table 5.28. Number of colleges with extra installations present in BSCS-user and EPB-user colleges

Equipment	BSCS-user laboratories	EPB-user laboratories
Centrifuge	2	0
Distilled water machine	5	1
Electric balance	1	1
Electric water bath	5	5
Microtome machine	5	0
Overhead projector	5	5
Slide projector	5	5
Electric balance	1	1

However, it is worth noting that the lecturers reported that most of this equipment is beyond the access of the students. The electric balance, microtome machines and centrifuge apparently used only by the lecturers.

5.55. An appraisal of the general provision

The present survey has revealed that biology laboratories of both BSCS- and EPB-user colleges are more often than not without electric light. Ceiling lights are provided to the laboratories but in only one out of ten colleges were bulbs provided for these lights. No desk lamps are provided. In only one BSCS-user college is there an arrangement of extension wires and extra switch boards for benches.

Many of the laboratories surveyed were judged to be dark (seven out of sixteen EPB-user colleges and in 2 out of 6 BSCS-user colleges) since there was no provision for electric lights and the windows were covered with plants. One consequence was that in such colleges microscope work is carried out in the corridors.

Sinks and taps are installed in all the laboratories but either the pipe line is not connected to the water reservoir or there are timings for running water which do not always coincide with the timings of practical classes. In 5 out of 16 EPB-user colleges and in one out of 6 BSCS-user colleges water is either kept in buckets or is fetched from else where when needed.

In newly built colleges sinks are set into the working tables and one or two laundry sinks are also provided. But at the time survey was taken water connections were not provided to these sinks.

Gas supply is provided only to 3 out of 16 EPB-user colleges and in the remaining 13 either spirit lamps are used or electric heaters. In BSCS-user colleges in a quarter of the biology laboratories available for Intermediate classes gas is used while in the rest spirit lamps are used.

These results indicate that the laboratory provisions do cause a constraint in running inquiry lessons.

CHAPTER 6

THE PERFORMANCE EVALUATION

6.10 Introduction

Performance evaluation is concerned with the effects of the curriculum on the performance of students. Students' performance is then used as a measure of the success or failure of the curriculum. Exclusive use of achievement tests to measure its success or failure is criticized for being too narrow an approach to evaluate a curriculum. Nevertheless, assessment of students' performance is considered as one of the important areas for a comprehensive evaluation of a curriculum. Since,

> "ultimately, education is about children and their teachers. It may be the case that evaluation which concentrates solely on narrowly defined outcomes omits information which is useful, but evaluation which omits consideration of outcomes altogether is omitting the core of process."
> (Williams, N (1981) p.82).

Two types of test are used for the assessment of students' performance namely, norm-referenced and criterion-referenced tests. Norm-referenced tests 'measure an individual's performance in relation to the performance of others on the same measure'. (Popham and Husek (1971) p.17).

On the other hand,

> "Criterion-referenced assessment provides information about the specific knowledge and abilities of pupils through their performance on various kinds of tasks that are interpretable in terms of what pupils know or can do, without reference to the performance of others".
> (Brown (1980) p.14)

Popham (1975) has emphasised the use of criterion-referenced tests in curriculum evaluation. He prefers criterion-referenced testing to norm-referenced testing for the reason that norm-referenced testing does not discern what aspects of any instruction need improvement nor does it reveal the aspects for which instruction has been successful. Popham (1973), as quoted in Brown (1980), argues in favour of criterion-referenced tests,

> "Because criterion-referenced tests need not produce considerable score variance, they can consist even of items which after instruction, most learners answer correctly. They can retain items which are based on the primary curricular emphasis. As a consequence, such tests are characteristically more sensitive than norm-referenced tests for purposes of detecting instructional effects".
> (Popham, J.W. (1973))

From the mid 1980s there has been an increasing emphasis on criterion - referenced testing, particularly in the case of science curricula in which the emphasis is on the assessment of what pupils and students can do with reference to both subject matter and skills. These trends are apparent in America, as Holdzkom and Lutz (undated), have mentioned in their discussion of criterion-referenced testing and in Britain, as is indicated by the Science Education Policy document (DES (1985a)), there is considerable emphasis on the introduction of diagnostic assessment procedures into teaching and of criterion-referenced assessment into the certification of pupils.

The present study is mainly concerned with the assessment of the extent to which science process skills are being taught and learnt in biology classes at Intermediate level. Since the purpose was to estimate whether or not biology students have developed a competence in science process skills, the criterion- referenced method of assessment was judged to be appropriate to us.

The decision to use criterion-referenced testing on this occasion is based upon the fact that it is the actual level of performance of students that is the focus of attention and not their relative performance. Such testing, as pointed out by Ward (1970), requires that the objectives of the test be teased out into specific behaviours against which a student's performance can be compared and decisions about achievement of competence made.

Science process skills as revealed from the literature can be taught and assessed by breaking them down into specific behaviours which a student will show if she/he had acquired the competence in the use of skills. Hence science process skills lend themselves easily to criterion—referenced assessment.

6.11. Strategy used in development of criterion-referenced tasks

In the present study the criterion-sampling approach is used. It is a form of criterion-referenced assessment in which performance of students is assessed on a sample of the criterion behaviour for which they have been trained. It requires first to identify the whole range of behaviours for which the training is being provided and then a sample of these behaviours is taken and the students' competencies in them assessed. In this study the students' performances that were to be tested were those concerning inquiry skills. The first step, therefore, was to identify the skills which are classified as inquiry skills. From the review of the literature (given in chapter 2) the skills encompassed as inquiry skills were identified and a list of 25 such skills in science was compiled based on those most commonly included in the lists of science process skills given in the literature.

In order to take a sample of these skills for inclusion in the criterion sampling assessment (CSA), the list of 25 skills was sent to a group of 12 biology lecturers from male and female Intermediate and Degree colleges in Pakistan. The lecturers were given a ten-point scale ranging from low to high score (i.e. 1 to 10) and they were asked to rate a real and an ideal Intermediate biology student on each of them. From the replies of the lecturers eight skills were identified at which they thought their real students were most competent. From the eight skills six were then randomly selected using random-sample table. These skills were,

(i) skill of making observations
(ii) skill of classifying objects and organisms
(iii) skill of making predictions
(iv) skill of making graphs, charts, tables
(v) skill of interpreting graphs, tables and charts
(vi) skill of choosing appropriate apparatus for an experiment.

Having identified the sample of the skills to be tested, the next step was to design tests to assess student competency in each of them.

Each of these skills can be used on different occasions. For instance, skill of observation is required in making microscopic studies and naked eye observations.

Although a student should, on all occasions, make relevant, accurate and complete observations, it is not feasible to test them on all such occasions. So it was tested on a sample of occasions and this sample was obtained by random means in order for it to be a representative sample. The experiments given in the Students' Practical Guide 'An Inquiry Into Life', were studied and for each skill to be assessed, a list was compiled of occasions/activities in which it would be exhibited. From these lists the occasions were taken.

Task 1

Three tasks were developed to test for student competency in observation by requiring them to make accurate, complete and relevant observations.

In task one coded here as O1, students were given a prepared slide of a micro-organism and were asked to observe and draw a diagram of it.

In the second task on observation (O2) students were given three chemicals and were asked to test two materials with these chemicals and write down their observations. In task three on observation coded as O3, students were given two copies of the diagram of circulatory system of the frog with 18 differences between the diagrams and they were asked to identify the differences.

Task 2

Three tasks were developed to test for student competency in making graphs, coded as G1, G2 and G3. In task G1 students were given second hand data and were asked to plot a graph. In task G2 students were required to collect their own data and were asked to plot a graph. In task G3 the students were given new data and were asked to plot a bar graph.

Task 3

One task coded as I, was developed to test for the level of student competency in interpreting and reading graphs.

Students were given a graph and questions were asked requiring them to interpret and read the graph.

Questions were asked so as the students had to read value of x on the x axis given value of y and value of y on the y axis given value of x. They needed to be able to follow the overall effect of the independent variable on the dependent variable.

Task 4

Task 4 coded as C was developed to test the student competency in classification using shells and a classification key. The key was kept simple, avoiding any terminology which could hinder the use of key.

Task 5

Task 5 coded as P was developed to test for student competency in making prediction. They were asked to predict what would be the appearance of an apple if it is cut in half in the horizontal plane i.e. in transverse section.

6.12. The pilot study

Each of the tasks was subjected to pilot study carried out in Pakistan in six colleges, two female Degree colleges and two male Degree colleges, one female and one male Intermediate college. Two student were taken from each of these six colleges, these being volunteers. Each CSA task was administered in the biology laboratories of these colleges.

The purpose of pilot study was (a) to fix criteria of assessment for each task and, (b) to determine the competency level for each skill.

For each task a check list of behaviour was compiled by the researcher. This list was discussed with the biology lecturers of the college before administering the task to the students. As a result of these discussions the checklist for some of the tasks was modified and the number of criteria that had to be met for competency was agreed to and set. In some cases, however, the lecturers could not agree on this number before seeing the students' performance and particularly so in the case of the skill of making graphs.

In such cases after administering the tasks the students' scripts were discussed with the lecturers and then the criteria was set and the score needed for competency was determined and agreed upon. It was then not changed for the duration of the pilot study. Below and on the following page for each task, the method used to determine the criteria and the score required for competency is given.

Task 01

Observation of a microscopic organism.

A slide of a micro-organism (in fact, a slide of Vorticella) was fixed under high power of a microscope and students were asked to observe and draw the organism. Students were invited to label and name the specimen but this was optional. The students were asked to make observations without moving the slide, though they were allowed to use microadjustments should they need to. The slide was closely observed by the researcher and the lecturer (using the same microscope as to be used by the students) before administering the task to the students. Some lecturers mentioned the danger that a student who observed correctly but could not draw the specimen might be considered unfairly not to have reached the level required for competency. The list of criteria was again discussed and it was judged to be appropriate even in such cases since the list did not included items such as the fineness of lines drawn and the beauty of the diagram. The criteria for 01 presented to the lecturers and the final agreed upon criteria are given below. For details of the task see Appendix 601.

(A) Criteria presented to lecturers as a basis from which to determine the final criteria:

1. Specimen drawn can be recognised as being the one on the slide.
2. Nucleus is shown in the diagram.
3. Shape of the nucleus is the same in the diagram as in its original specimen.
4. Nucleus shown at the same place as in the specimen.
5. Stalk drawn.
6. Cilia shown.
7. Vacuole drawn.
8. Size of the nucleus is comparable to the whole body .
9. Size of the diagram comparable to the specimen.

Maximum possible score = 9

(B) Final criteria: Agreed upon after discussions with lecturers:

1. Specimen drawn can be recognised as being the one on the slide.
2. Nucleus is drawn at the same place as in the specimen.
3. Shape of the nucleus drawn is similar to the nucleus of the specimen drawn.
4. Nucleus drawn at the same place as it is in the specimen.
5. Stalk drawn as is seen in the specimen.
6. Upper rim of the bell-shaped body drawn thicker and darker than the rest of the body.
7. Spring-like portion seen at the base of the body is shown in the diagram.

Maximum possible score = 7

Score required for competency = 5 If labelled and/name given = +1

The lecturers did not agree to include criteria 7,8 and 9 of list compiled by the researcher. The 6th criterion of the original list (i.e. list A) was also modified, since cilia were not clear and only the upper rim of the body of the specimen looked darker and thicker than the rest of the body. The same criteria were used in the final study (see section 6.3).

The students were given the task and when the students had finished the drawing to his/her satisfaction the lecturer and researcher independently looked at the diagram drawn and the slide and marked the correct items and then compared the results. The final criteria was judged to be simple and appropriate for the task given.

On the basis of the criteria finally agreed upon, three out of twelve students who undertook this task reached the level of competency.

Task 02

Observation of differences in two diagrams.

In this task the students were given two copies of the circulatory system of the frog with 18 differences built into them. The lecturers agreed on 15 as the score for competency in observation. However, they did not agree with the idea of this task. Their major objection was that this task will not tell about the competency of students developed due to the practical work in biology since some students are used to such tasks given in the newspapers and magazines while others are not.

They also said that it was too simple for Intermediate stage to judge their competency in skill of observation. Out of 12 students who undertook this task 7 students reached the level of competency.

In the final study this task was replaced by another microscope observation task (details of which are given in section 6.3 and Appendix 602).

Task 03

Observation and recording of effect of chemicals on materials.

Students were given two materials, A and B, and were asked to test each with the chemicals 1, 2 and 3. They were asked to record their observations on the answer sheets provided. The results to be seen are given in the Table 6.1. For details of the task see Appendix 603.

Table 6.1: Criteria for task O_3

Material	Chemicals		
	1	2	3
A	Material turns black	Bubbles are formed, slight change in temperature	Colour changes to light green
B	No change in material	Gas bubbles are formed, slight change in temperature	Colour changes to red

The maximum possible score was 6 with an extra mark each time the change in temperature was recorded. In fact, in the final study these two factors were included into the list of criteria for this task making competency attained by showing 5 out of 8 criteria.

Each student was given six glass tubes with materials and the lecturers and the researcher added the required amount of chemical in each test tube when the student was ready for this task. It was done to make sure that the students test the materials in the same way and to ensure their observations are not effected by the amount of chemical or material used. The observation recorded were compared with the actual results by the researcher and the lecturer to mark the check list.

Task C

Identification of shells using a key.

Eight shells were provided to the students and they were given a key to identify each shell. The lecturers objected to this task and said that it is only at Intermediate stage that students start learning the use of keys. First year students have not done this task yet, hence they have no idea of using the key.

The task was administered and it was observed that first-year students were not able to use the key. Even in second-year classes all the students could not use the key and said they are not familiar with this kind of work. When given the task 2 students out of 12 students reach the level of competency.

In view of lecturers' objections and criticism this task was not included in the final study since in addition there was little chance that, in the final study, second-year students will be available as that study would have to be made near the time of their examination.

However, the lecturers said, if a student knows the use of the key he/she should be able to identify all the shells.

Task G

Plotting graphs.

To test the students' competency in making graphs three tasks were included in CSA. These tasks were as follows:

(a) Plotting a line graph using the second-hand data G1

(b) Plotting a line graph using first-hand data G2

(c) Plotting a bar graph using second-hand data G3

Task G1

Drawing a line graph from second-hand data.

Student were given second hand data and they were asked to draw a graph of them. Each student was provided with similar graph paper, a ruler, a sharpened pencil, rubber and sharpener.

The criteria were discussed with the lecturers before giving the task to students but on many points the lecturers could not agree that criteria 3 and 4, 8 and 9 be included in the checklist. So, after administration of the task students' scripts were discussed and final criteria were successfully determined.

Criteria presented to the lecturers as a basis from which to determine the final criteria.

1. Line for x axis drawn
2. Line for y axis drawn
3. Correct choice of variable for x axis
4. Correct choice of variable for y axis
5. x axis fully labelled, giving variable name and unit
6. y axis fully labelled, giving variable name and unit
7. Point of origin of graph correct
8. x axis extended half way across the graph papers
9. y axis extended half way up the graph paper
10. Scale for y axis correct
11. Scale for x axis correct
12. All points marked correctly
13. A line joining the points drawn
14. Caption of the graph given
15. Key for x axis given
16. Key for y axis given

Total maximum possible score = 15

(after joining 3 and 4)

Score required for competency = 9

(See Appendix 6G for details of task and final criteria)

From the students' results it was agreed that the criteria 3 and 4 are important but it was decided to merge them into one since if the variable chosen for one axis was correct then the variable used for the other axis was also correct.

The lecturers added two more criteria to the list, namely, key for the x axis provided and key for y axis provided. A key, in this instance, is description of the scale chosen for x axis and y axis; that is how many smallest divisions/largest divisions of graph paper are taken as equal to the unit in which variable is measured.

For this task a score of 9 was considered as the score required for competency. It was also decided if a student plotted the wrong variable on the x axis and the y axis he/she should be considered as not reaching the level of competency regardless of the final score attained.

The lecturers did not agree with the importance of the length of x axis and y axis in graphs and said it does not make much difference. However, on seeing the pilot students answers they agreed to retain criteria 8 and 9.

In the pilot study 5 out of 12 students reached the level of competency.

Task G2

Drawing a graph from first hand data. Due to time constraints this task was not performed.

Task G3

Plotting a bar graph from second-hand data.

To test student competency in drawing bar graphs, students were given second-hand data and were asked to plot a bar graph. Once again each student was provided with pencils, graph papers, rubbers and sharpners.

The criteria were mostly the same as for line graph, but with the addition of criteria suitable for a bar graph:

- Distance between all the bars is equal
- Bars drawn for different groups of data distinguishable from one another.

However, by the time this task was given to the students they strongly objected to it and said that there was too much graphing in this activity and in biology there are very few experiments in which they are required to draw graphs. Lecturers were of the same opinion and said that most of the graph work is done in physics, there are very few biology experiments which require the students to present their results in graph form. Two out of 12 students reached the level of competency.

Students were clearly bored and showed their unhappiness. The task was performed very reluctantly. In the final study a single graph task was set which was to make a line graph from second-hand data.

Task I

Interpreting and reading a graph.

To test student competency in interpreting and reading line graphs a task was set out and students were asked to read the value of x axis, given the corresponding value of y and a value of y axis given a corresponding value of x. There were also questions which require the students to interpret the graph by describing the overall effect of the independent variable on the dependent variable.

In all, 5 questions were set and a score of 4 was considered as evidence for having reached the level of competency. Students and lecturers found the task easy and interesting. However, the lecturers were of the opinion that with one graph and five items to answer the ability to interpret and read the graph cannot be assessed fairly. On the basis of these comments, in the final study two graphs were included to test student competency in interpreting and reading the graphs. (See section 6.3 for details). Ten out of 12 students reached the level of competency in the pilot exercise.

Task P

Making Predictions.

To test student competency in making predictions two tasks (P1, P2) were included in the CSA in pilot study.

In P1 students were asked to predict what would be the appearance of an apple it it is cut through the middle in half in the horizontal plan, i.e. in transverse section.

The criteria for this task were developed with the help of the lecturers. The criteria developed were as follows:

(1) Five seed chambers drawn
(2) Five seed chambers drawn in radial arrangement
(3) Seeds shown
(4) Outer portion of pericarp shown
(5) Chamber drawn in the centre.

One criterion relevant to the students' ability of cutting a transverse section was suggested by one lecturer, but after discussions it was judged to be irrelevant in this instance.

The task was administered and it was observed that the students had no concept of the structure of apples anyway. Those who (2 out of 12) could draw it said they have seen the structure many times. Lecturers rejected this task since it was based on knowledge. Even so they set the criteria of minimum 3 score as the competency level.

This task was not included in the final study.

Task P2

Predict the Result of an Experiment.

To test student competency in making predictions another task was also given.

Students were asked to predict the results of six experiments involving transpiration from leaves of a plant. This task was performed by 12 students and 7 students reached the level of competency. This task was retained in the final study.

For details of the task see section 6.20. The criteria set in the pilot study was used in the final study. No changes were deemed necessary. See Appendix 6P for the tasks and criteria used in the final study.

6.20. Field trials of CSA for final study

First field trials reported is section 6.11 resulted in major changes to the original CSA plan and tasks. One of the major changes was the replacement of tasks on skill of classification by tasks on skill of making measurements. Skill of making measurements was one of the 8 skills at which lecturers thought their students were best. Changes were also made in the tasks on the assessment of competency in the skills of observation of plotting graphs and of the interpretation of graphs. In some cases new tasks were added. In others the tasks used in the first field trials were modified in the light of the results of the first field trials.

The skills included in the final study were as follows:

(1)	Skill of making observations	O
(2)	Skill of taking measurements	M
(3)	Skill of plotting graphs	G
(4)	Skill of reading and interpretation of graphs	I
(5)	Skill of choosing appropriate apparatus for a given experiment	A
(6)	Skill of making predictions	P

<u>O Skill of making observation.</u>

In order to test students' competency in making observation three tasks were included in the full sample of students subjected to CSA based assessment namely:

O1 - Observation of a micro-organism
O2 - Observation of the effect of a chemical on the lower epidermal cells of a leaf
O3 - Observation of the effects of three chemicals on two materials.

All three tasks were given to each student. Task one (O1) was the same as used in the first pilot study (see section 6.12 and Appendix 601)

In order to standardize the task in the final study the same individual slide of Vorticella was used in each college. The slide was brought from the U.K. and was closely observed by the lecturers in Pakistan and by the researcher. The criteria used in the first field trials were judged to be appropriate.

In the final study it was decided that each student will be helped to use the microadjustment of microscopes since students may not be able to focus the slide and it might effect their performance.

Students were asked to draw the specimen under the high power of the microscope. The best available microscopes were used for this task. The name of the micro-organism was sealed under a slip of paper.

Each student was provided with a sheet of paper, a pencil and a rubber. Both the researcher and the lecturer checked each student's work by comparing it with the specimen. Final scores were given by consensus of opinion between the lecturers and the researcher. The full final set of criteria for the task has been given elsewhere (see section 6.12 and Appendix 601).

Task 02

In this task students were asked to observe a temporary slide of the lower epidermis of a leaf and draw a portion of it showing their observations. They were asked to show their drawing to their teacher and researcher without moving their slide. Then they were asked to drain the water from their slide and add the solution provided (5% glucose solution was provided). They were asked to observe the slide once again and record their observation after addition of the solution. They were asked to show their drawings of the second observation without removing their slide from the microscope.

After field trails it was decided that each student will be given the prepared temporary slide so as to eliminate the effect of bad/good mounting of the slide on their performance. Secondly it was decided that the researcher and lecturer would drain the water and add glucose solution on students' slide. It was time consuming but was found appropriate for the purpose of study. (See Appendix 602 for details of the task).

The criteria agreed to were as follows:

(1) The part of the specimen drawn recognisable on the slide
(2) The outline of the epidermal cells drawn correctly as seen
(3) Cell wall shown
(4) Guard cells shown
(5) Kidney-shaped guard cells shown
(6) Difference in the thickness of inner and outer wall of the guard cells shown.
(7) Chloroplast in the guard cells shown
(8) Stomatal openings drawn as seen

For the second observation the same criteria were used. Total possible score was 8 + 8 = 16. Score set for competency was 10 for each of these two observation tasks.

Task 03

In this task students were given two materials and were asked to test each of them with three chemicals and observe and record their observations. The same criteria were used as in the pilot study.

In order to determine competency in skills of making observations the scores obtained in three tasks were added and then competency was determined (see Appendix 603). The overall score set for competency was 20 or more.

Task	Maximum possible score	Score required for competency
01 Microscopic observations	7	5
02 Naked-eye observations	6	5
03 Microscopic observation of change	16	10
Total	29	20

M skill of taking measurements

In the final study this skill replaced the skill of classification. Three major tasks were developed and given to all students in the sample to test for competency in taking measurements. These tasks were as follows:

M1 Skill of measuring volume of water in graduated cylinders

M2 Skill of measuring temperature using clinical thermometer

M3 Skill of measuring mass of a metal block

Two tasks were developed for M1 namely M1' and M1" one task for M2 and one for M3 were included in CSA.

Task M1'

Read the volume of water in three cylinders A, B and C. Record your readings for each cylinder. This task was tried first in the University of Keele and then in Pakistan. Originally it was decided that the researcher will measure the fixed amount of water in the cylinders and both the researcher and lecturer will read the volume to check the accuracy. After administration of the task the water will be weighed in the beaker of known mass to further ascertain the accuracy of the measurement. Beakers were weighed in the University of Keele and were taken from the U.K. to Pakistan for this purpose. But the weighing balances available in the colleges in Pakistan were themselves so defective that there was little benefit in using this method. The electric balances, wherever available, were either locked away or could weigh only a maximum of 100 grams. In the end only the first method was used for checking the measurements. In each of the three readings an allowance of 1 of the smallest scale division was made. A score of 3 was set as the level for competency requiring the students to read all three values to the degree of accuracy stipulated.

Task M1"

In this task students were asked to measure a given amount of water in the cylinders provided. Originally it was decided to use the same three cylinders for all students and give the task to the students one by one. But in the field trials it was found to be time consuming and impractical. So each student was given three measuring cylinders and each was asked to measure out three given quantities in each cylinder and leave the cylinder on their desk. Each cylinder was marked A, B or C and students were asked to measure a given quantity of water in each cylinder.

After they had measured the water readings were taken both by the lecturers and researcher and the score was given to the student.

An allowance of 1 of the smallest scale division was given for each measurement. A score of two was required for competency, so a student would have to make 2 out of 3 possible measurements to the required degree of accuracy.

Task M2

In this task students were asked to read the temperature on clinical thermometers. Three clinical thermometers were given to each student. Clinical thermometers were used because since the temperature was set on them it remained constant for a day. During the trials it was found that students held the thermometer by its bulb and often shake it. In the actual study, instructions were displayed in bold letters near the thermometers which read as follows:

(a) DO NOT HOLD THE THERMOMETER BY ITS BULB

(b) DO NOT SHAKE THE THERMOMETER

(c) DO NOT PUT THE THERMOMETER DOWN EXCEPT IN ITS CASE

These were written in the national language and were also read out loud. Each thermometer and its case was marked as A, B or C. Temperature was set and both the lecturer and researcher recorded the readings of each thermometer. After a student has used the thermometer the thermometer was checked in case any change has taken place that would effect the next student's performance.

An allowance of 1 smallest scale division was given for each reading and a score of three was required for competency.

Task M3

Mass of a given block of metal.

Originally it was decided to give three blocks of metal to the students to weigh. These blocks were weighed three times at the University of Keele in the U.K. and an average mass of each block was recorded. During the field trials it was found that the lecturers did not allow their students to weigh more than 100 grams on the weighing balance. They allowed the researcher to weigh only the small block which was of 67.215 grams. So in the final study only one block was given to the students in the CSA tests.

It was decided to set the criterion for competency for each college individually depending on the condition of the weighing balance available. Error allowance was set after weighing the block and finally after observing students' performance on the balance. In some colleges the error allowed was agreed upon and set at one per cent and in others it was agreed upon and set at two per cent, depending on the condition of the weighing balance. Very rarely the weighing balance was found to be in appreciably good working order. Details are provided in Table 6.2.

Table 6.2: Condition of weighing balance available in the laboratories of EPB—User and BSCS—User colleges

	COLLEGES EPB	BSCS
- No balance available	6	1
- One weighing balance	2	1
- More than one weighing balance all defective	3	0
- Weighing balance packed away	2	0
- Weighing balance shared with other labs.	1	2
- More than one weighing balance and all in working order	2	2
Total colleges	16	6

Table 6.3. Summary of scores for CSA tests concerning measurement.

Task	Maximum possible score	Score required for competency
M1 Measurement of volume of liquid in graduated cylinder		
M1'	3	3
M1"	3	2
M2 Measurement of temperature using clinical thermometer	3	3
M3 Measurement of mass of a metal	1	1
Total scores	10	9 / 8*

*A score of 8 was set for those colleges where the task on weighing the metal was not carried out.

To determine overall competency in skill of measurement the score obtained in each task was added and then on the basis of the total score student's competency in the skill of measurement was determined (see Appendix 6M).

Task G

Skill of plotting a graph.

To test students' competency in plotting graphs one task was developed. Students were given second-hand data and were asked to plot a graph of the data. Graph papers, pencils, rubbers, rulers and sharpeners were provided to each student.

The criteria set in the first field trials were discussed with the lecturers and were judged to be appropriate for this task. (See section 6.12 for details). See Appendix 6G for the task.

The score set for competency was 9. However, any student who plotted the wrong variable on the x and y axis was judged to be below the level for competency even if he/she achieved a score of 9 or more.

After looking at the student's performance lecturers agreed that in Pakistan a score of 6 will also be acceptable if a student has shown six criteria (Numbers 3-8 below) considered essential for acquiring a competency. Below, the criteria are given and the criteria considered essential identified.

Criteria	
1. Line for x axis drawn	
2. Line for y axis drawn	
3. Point of origin correct	Essential
4. Correct variable chosen for x and y axis	Essential
5. Scale for x axis correct	Essential
6. Scale for y axis correct	Essential
7. All points marked correctly	Essential
8. Points joined with smooth/ ruler line	Essential
9. y axis labelled	
10. x axis labelled	
11. Key for x axis given	
12. Key for y axis given	
13. Caption of graph given	
14. y axis half way up the paper	
15. x axis half way across the paper	

The scripts were marked first looking for six essential criteria and then for others.

Task I

Interpretation and reading of graph.

To test student competency in the skill of interpretation and reading of graphs two tasks were included in CSA namely, I1 and I2.

In each task three questions were about the overall effect of the independent variable, which in both cases was temperature, on dependent variables, which in both cases was the population of three animals. In each task six questions were such that the value on one axis was given and student had to read the value on the other axis. For these questions an error allowance of 2 smallest graph divisions was given. Overall competency in the interpretation of graphs was determined again by adding the scores obtained in both tasks. For competency a student had to answer 10 questions correctly out of the 18 set. See Appendix 6I1 and 6I2 for details of the tasks.

Task A

Skill of choosing appropriate apparatus for experiments.

To assess student competency in choosing apparatus for an experiment they were asked to collect all the apparatus they thought they would need to perform the experiment. This task was not administered in all colleges because students said that they have not remembered the apparatus by heart as yet so cannot perform this task. In both EPB and BSCS colleges the students who attempted to perform this task had already performed the experiment in class and knew the apparatus. So the results of this task are not given here.

Task P

Predict the possible results of the experiment demonstrated.

To test student competency in making predictions, they were shown six experiments on plant leaves and in each case results were predicted by the students before seeing the actual results.

Students were asked not to change their answers if their predicted result was different from the actual result. The task was demonstrated and instructions given on the answer sheet were read out during the demonstrations. A score of 4 out of score of a maximum of 6 was set as the criteria for competency. (See Appendix 6P for details of the task, and section 6.2).

6.30. The results of the criterion-referenced assessment

The competencies of the students on each of the five skills included in the criterion-referenced tasks is determined for boys and for girls of Degree and Intermediate colleges and for both EPB-user and BSCS-user colleges. Chi-square was used as the bases of the analysis but could not be used when the expected frequency of any cell was very small indeed. On such occasions Phi—coefficient was calculated instead.

The results are discussed below and on the following pages. For the detailed results of performance of each student on each of the five skills see Appendix 6.1.

6.31. The performance of the students attending EPB-user Degree colleges

A summary of results is given in Table 6.4. In order to test if the number of students in female and male EPB-user Degree colleges who reached the level of competency differed significantly. The phi-coefficient was computed for each of the skills.

Table 6.4: Number of students who attained and those who did not attain the level of competency in five skills in EPB user Degree Colleges. Percentage in brackets.

Skills	Girls (n=28) Reached the level of competency	Did not reach the level of competency	Boys (n=27) Reached the level of competency	Did not reach the level of competency	ϕ	Probability
Observation	14(50)	14(50)	07(27)	20(73)	0.248	$P > 0.05$
Measurement	10(36)	18(64)	17(65)	10(35)	0.272	$P < 0.05$
Graphing	13(46)	15(54)	12(46)	15(34)	0.020	$P > 0.05$
Interpretation	08(28)	20(72)	10(38)	17(62)	0.090	$P > 0.05$
Prediction	10(18)	18(64)	11(42)	16(58)	0.052	$P > 0.05$

The results show that in four out of five skills there is no statistically significant difference in the number of boy and girl students reaching the level of competency. However, for the skill of taking measurements statistically significantly more boys than girls achieved competency. The difference is significant at $p<0.05$.

A glance at the numbers of boys and girls who achieved the level of competency in each of the five skills namely, observation, measurement, graphing, interpreting and reading graphs and prediction, shows that in none did all the boys or all the girls reach the level of competency set for this study, surprisingly in the skill of making observations, for it is rated highly in importance by the lecturers and by the students. Only fifty per cent of the girls and about one quarter of the boys reached the level of competency. It is one of the strongest skills in EPB-user colleges for boys.

6.32. The performance of the students attending EPB-user Intermediate colleges

The CSA tasks were administered in six colleges, three of which were male colleges and three were female colleges. Altogether thirty students performed the CSA tasks (17 girls and 13 boys) and the results are summarised in Table 6.5.

Once again a phi coefficient was computed to test if there was a statistically significant difference in the number of students in male and female colleges who reached the level of competency. The test was computed for each of the five skills.

Table 6.5: Number of students who attained the level of competency and those who did not attain the level of competency in EPB User Intermediate colleges for boys and girls. Percentage in brackets.

Skills	Girls (n = 17)		Boys (n = 13)			
	Reached the level of competency	Did not reach the level of competency	Reached the level of competency	Did not reach the level of competency	ϕ	p
Observation	10 (59)	7 (41)	4 (31)	9 (69)	0.279	$p > 0.05$
Measurement	11 (65)	6 (35)	7 (54)	6 (46)	0.110	$p > 0.05$
Graphs	2 (12)	15 (88)	2 (15)	11 (85)	0.053	$p > 0.05$
Interpretation	4 (24)	13 (76)	3 (23)	10 (77)	0.005	$p > 0.05$
Prediction	4 (24)	13 (76)	8 (62)	5 (38)	0.384	$p < 0.05$

The results (Table 6.5) show that in four out of the five skills there is no statistically significant difference in the number of male and female students who achieved the level of competency.

However, in the skill of making predictions there was a statistically significant difference but this time with more boys than the girls reaching the level of competency. The difference is as tested by the phi coefficient is significant at $p<0.05$.

Once again in none of the five skills did all the boys and all the girls reach the level of competency. In the case of girl students noticeably more students reached the level of competency in the skills of observation and measurement than in the other skills, in which only about one quarter of the female students achieved the level of competency. The skill of making graphs appears to be the weakest skill students in Intermediate colleges since only a small number of boys and girls achieved the level of competency in this skill.

The skill of interpreting and reading graphs is also one of the weak skills in both male and female Intermediate colleges since a small number of students achieved the level of competency in this task.

However, it is surprising that the skill of making observations, which is considered very important by the lecturers and the students, is again not the strongest skill. Indeed, the strongest skill is prediction in the case of students in male colleges and measurement in the case of students in female colleges which is surprising for these skills are not given top priority by the lecturers and particularly the skill of making predictions which was found to be far behind in importance compared to the skill of making observations. In all the interviews lecturers claimed that observation is the basis of knowledge and this skill stood out from the others in the questionnaires, but that does not seem to have been reflected in the performances of students.

6.33. The performance of the students attending BSCS-user colleges

A summary of results is given in Table 6.6. In order to test if the number of students in female and male BSCS-user Degree colleges who reached the level of competency is significantly different the phi coefficient was computed for each of the skills. In three out of five there is no statistically significant difference in the number of boy and girl students reaching the level of competency. But for the skill of making graphs and making prediction statistically significantly more boys than the girls reached the level of competency. The strongest skill in these colleges appeared to be measurement since most of the students reached the level of competency in this skill. The skill of making graphs is the weak skill in degree colleges for girls since none of the female students attained the level of competency in it. Overall results reveal that more boy students than the girl students reached the level of competency in these skills, though the difference is not statistically significant in all cases.

During the study, from the results of the interviews questionnaires and observation schedule, it was found that the lecturer in one of the two male BSCS-user Degree colleges was more aware of the BSCS approach than the rest of the lecturers interviewed or observed. His practices and views revealed an effort on his part to adopt BSCS materials and its approach.

Table 6.6: Number of students who attained the competency level and the number of students who did not attain the competency level in BSCS User Degree colleges.

Skills	Girls (n = 10)		Boys (n = 11)			
	Reached the level of competency	Did not reach the level of competency	Reached the level of competency	Did not reach the level of competency	ϕ	p
Observation	5 (50)	5 (50)	8 (73)	3 (37)	0.234	$p > 0.05$
Measurement	9 (90)	1 (10)	11 (100)	0 (00)	0.234	$p > 0.05$
Graph	0 (00)	10 (100)	8 (73)	3 (37)	0.748	$p < 0.05$
Interpretation	6 (60)	4 (40)	10 (91)	1 (09)	0.362	$p > 0.05$
Prediction	4 (40)	6 (60)	9 (82)	2 (18)	0.430	$p < 0.05$

To find out if the boy students who reached the level of competency were more often from this particular lecturer's class the performances of the students of the two BSCS-user Degree colleges included in the study on each of the 5 skills were compared (see Table 6.7). Again phi-coefficient was computed to test if there was a statistically significant difference in the number of boys who reached competency level in each one of these colleges compared to those in the other colleges and in each skill. The comparison shows that in four out of five skills there is no statistically significant difference, but in the skill of making observation statistically significantly more boys from this perceptive lecturer's class reached the level of competency ($p<0.05$). It is notable that the lecturer has developed a set of criteria for his assessment of observation work in biology practical classes. He gives his criteria to the students and they work accordingly. The fact that all of his students reached the level of competency in this skill indicates that this approach to observation work has its effect upon students performances.

Table 6.7. Comparison of performance of students from BSCS degree colleges for boys (n = 5 and 6)

Skills	College 1 No. of boys who reached the level of competence	College 1 No. of boys who did not reach the level of competence	College 2 No. of boys who reached the level of competence	College 2 No. of boys who did not reach the level of competence
Observation	2	3	6	0
Measurement	5	0	6	0
Making graphs	3	2	5	1
Interpretation	5	0	5	1
Prediction	4	1	5	1

6.34. Comparison of performance of students from BSCS-user and EPB user colleges

The results for females in EPB-user Degree colleges and the results for females in BSCS-user Degree colleges were compared and similarly those for the males in EPB-user and BSCS-user Degree colleges were compared in order to establish whether or not there is evidence that the textbook for the course affects the incidence of competency. A summary of the results has been given in Table 6.8 and Table 6.9.

In order to test if there is a statistically significant difference in the number of students who reached the level of competency phi coefficient was computed for male and female Degree colleges respectively and for each skill the results are given in the Tables.

The results show that in three out of five skills there is no significant difference in the number of girl students in BSCS-user and EPB-user colleges who attained the level of competency. In the skill of taking measurements, proportionally more girl students from the BSCS-user colleges than from the EPB-user colleges attained the level of competence, the difference being significant at $p<0.05$. But in the skill of making graphs, none of the students from BSCS-user colleges for girls attained the level of competence while in EPB-user colleges about half of the total number of students who performed the task reached the level of competency and this difference is statistically significant ($p<0.01$).

In none of the two types of colleges did all the students attain the level of competency in any of the five skills. In EPB-user colleges observation is one of the strongest skills, while in BSCS-user colleges measurement appears to be the strongest skill.

Table 6.8: The number of students who reached the level of competency and those who did not reach the level of competency in each skill in EPB and BSCS Degree colleges for girls. Percentage in brackets.

Skills	EPB (n = 28)		BSCS (n = 10)			
	Reached the level of competency	Did not reach the level of competency	Reached the level of competency	Did not reach the level of competency	ϕ	p
Observation	14 (50)	14 (50)	5 (50)	5 (50)		
Measurement	10 (36)	18 (64)	9 (90)	1 (10)	0.478	$p < 0.01$
Making Graphs	13 (46)	15 (54)	0 (00)	10 (100)	0.431	$p < 0.01$
Interpretation	8 (28)	20 (72)	6 (60)	4 (40)	0.287	$p > 0.05$
Prediction	10 (18)	18 (64)	4 (40)	6 (60)	0.260	$p > 0.05$

Table 6.9: Comparison of the number of students who reached the level of competency in BSCS User and EPB User Degree colleges for boys.

Skills	EPB User colleges		BSCS User colleges			
	Reached the level of competency	Did not reach the level of competency	Reached the level of competency	Did not reach the level of competency	ϕ	p
Observation	7	20	8	3		
Measurement	17	10	11	0	0.434	$p < 0.05$
Making Graphs	12	15	9	2	0.322	$p < 0.05$
Interpretation	10	17	10	1	0.341	$p < 0.05$
Prediction	11	16	9	2	0.364	$p < 0.05$

In the case of BSCS-user and EPB-user Degree colleges for boys a comparison of the number who achieved the level of competency in each skill shows that, in all cases, the difference in the number of students who acquired the level of competency reached the level of statistical significance (see Table 6.9). According to these results significantly more boys in BSCS- user colleges reach the level of competency than the number reaching this level in the EPB-user Degree colleges.

In BSCS-user Degree colleges for boys all boys reached the level of competency in the skill of taking measurements. In both EPB-user and BSCS-user colleges the skill of taking measurements is the strongest skill. However, in these colleges also, like the Degree colleges for girls the skill of making observations is one of the weaker skills. which is contrary to what one might expect in the light of the lecturers' and students' priorities and perceptions. Although this skill is given a high priority by lecturers and students it does not stand out as the best skill in the performance of the students.

Summary

In both EPB-user and BSCS-user colleges measurement is one of the strongest skills, while graphing seems to be one of the weakest skills. The skill of observation is not one of the best skills, though it was expected that it would be, given the degree of importance which is attached to this skill by lecturers and by students.

When for each skill the proportion of students reaching the level of competency was calculated and the value of students at EPB-user colleges compared to that for students at BSCS-user colleges, it was found that for every skill, the proportion was higher in BSCS-user colleges (Table 6.10).

The figures in the Table 6.10 once again suggest that measurement is the strongest skill in both EPB-user and BSCS-user colleges and the proportion reaching competency in the skill of making observations is again not strikingly different from those for each of the remaining skills.

Table 6.10: Proportion of students achieving competency in each skill in EPB-User colleges and BSCS-User colleges.

College	Skills				
	Observation	Measurement	Graphs	Interpretation	Prediction
EPB-User (n = 85)	41	53	34	29	39
BSCS-User (n = 26)	58	88	38	65	54
Difference	17	35	4	36	15

6.35. Comparison of EPB and BSCS-user colleges with respect to the number of students who attained competency in each of the five skills

The results of all the students from EPB-user colleges (n=85) and all the students from BSCS-user colleges (n=26) are summarised in Table 6.11.

Table 6.11: Number of students from EPB-User and BSCS-User colleges attaining the level of competence in each of the five skills.

Skill	EPB	BSCS	chi-square χ^2	Probability
Observation	35	15	2.194	$p > 0.05$
Measurement	45	23	10.585	$p < 0.01$
Graphs	29	10	0.002	$p > 0.05$
Interpreting	25	17	10.950	$p < 0.001$
Prediction	33	14	0.02	$p < 0.05$

In order to test if there was a statistically significant difference in the number of students who achieve competency in each of the five skills in EPB-user and BSCS-user colleges the Chi-square test was computed. The results show that in the skill of taking measurements and of interpreting and reading graphs statistically significantly more students from BSCS-user colleges attained the competency. The difference is significant $p<0.01$ for the skill of taking measurements and at $p<0.001$ for the skill of interpreting and reading graphs. With regard to the remaining three skills the difference did not reach statistically significant levels.

6.36. Comparison of the number of students who attained competency in three and more than three skills in EPB-user and BSCS-user colleges

Since there is consistently, and for all five skills a higher proportion of students at BSCS-user colleges attaining the level for competency, it was decided to examine the data for evidence of BSCS students having a wider range of competency than students at EPB-user colleges. To that end the number of students reaching the level for competency in from none to five skills was established and the results are shown in Table 6.12.

Table 6.12: Distribution of students according to the number of skills in which they attained competency.

Students	Number of skills						
from	0	1	2	3	4	5	n
EPB-User colleges	8	31	17	18	8	3	85
BSCS-User colleges	1	6	1	4	11	3	26

For present purposes it was decided to group the data and raise just two groups of students namely, one group containing the number of students who only achieved competency in fewer than three skills and the other group containing the number of students who achieved competency in as many as three and more skills. The table of that data is shown in Table 6.13.

Table 6.13: Distribution of the students according to the number of the skills in which they attained competency.

Students from	Numbers of students achieving competence in: less than three skills	three and > 3 skills
EPB-User colleges	56	29
BSCS-User colleges	8	18

$$\chi^2 = 10.05 \ (p < 0.01)$$

To test if there was a statistically significant difference in the distribution amongst the type of college of the number of students achieving competency in three or more skills as against two or fewer skills the Chi square test for a 2 by 2 contingency table was computed. A value of $\chi^2 = 10.05$ was obtained which is statistically significant, having a probability of less than 0.01. According to these findings there is a statistically significant likelihood that the more widely skilled students will be in BSCS-user colleges.

Summary

The results of criterion-referenced tasks have revealed that there is a higher proportion of students reaching the level of competency in BSCS-user colleges than there is in EPB-user colleges and this has been found to be the case for each of the five skills tested.

In the case of skills of taking measurements and interpreting and reading graphs these differences are statistically significant at the 5% level. In both types of the college measurement is the strongest skill and the skill of making observations, contrary to expectations, is not one of the strongest skills in EPB-or BSCS-user colleges.

The BSCS-user colleges have the more widely skilled students in that those with competency in three to five skills tend to occur in these colleges, while students with two or fewer skills tended to occur in EPB-user colleges. This trend is statistically significant at the 1% level.

This finding is unlike those of the rest of this study in which no noticeable differences in the perceptions or the practices between the BSCS-user and EPB-user college was in evidence.

Since the findings of this study show that there is no evidence that the practices and perceptions in BSCS-user colleges are markedly different from those in EPB-user colleges (other than the textbook in use), it would appear that neither teaching practices nor perceptions of the lecturers account for the difference that has been found between the performance of the students in these two types of college regarding their competency in science skills. This suggests other factors have contributed to this difference and of these factors the one on which data was immediateley available concerns the ability of students on entry to the Intermediate biology course, as shown by their entry qualifications.

The entry qualifications of all the students taking part in the CSA tests were traced through college records. It was found, by means of the Chi-square test, that statistically significantly more students in BSCS-user colleges have A and A+ grades in their science subjects including mathematics than do those in EPB-user colleges ($p<0.05$).

6.40 Views on CSA approach of assessment and CSA tasks used in this study

6.41 Lecturer's views

The concept of criterion-reference assessment, on the basis of pre-determined criteria and in absolute terms of categorising the examinee into two categories of reaching or not reaching the level of performance required for competency, is new to the lecturers of Intermediate biology in Pakistan. The lecturers are more used to norm-referenced assessement, grading students in A+, A, B and C categories according to percentage marks obtained in an examination. Nevertheless, the majority of the lecturers who helped with CSA Tasks (15 out of 21) said they liked the approach. Particularly the less experienced staff saw advantages in the use of a criterion-referenced approach and they commented favourably on the criterion-sampling approach that was used as a part of this study.

In this respect they independently made three points. (a) This approach seems to make the assessment work much easier, though more experienced staff had reservations in this respect. They were not very sure if it would make the assessment an easy job in view of the fact that it involves a lot of work on teachers part beforehand, in the preparation of assessment lists, in deciding the level required for competency, and in marking each student's work on the basis of the list. Nevertheless, they did not reject the approach as being inappropriate or unfair. (b) Some of the lecturers appreciated the approach for it appears to them that it would reduce the chance of unintentional, or intentional, unfair judgements of students' work; with a clear key for assessment one cannot be very unfair in his/her judgements, they said. (c) It will also provide a clear idea of what a student can or cannot do, so the teachers could help the students better, knowing exactly what it is they are weak in. However, on one point the lecturers disagreed amongst themselves with the use of absolute categorising of students into just the two categories reaching/not reaching the level required for competence and suggested that even in such assessment we can have different levels of performance which, they said, would be more informative.

The five lecturers who opposed the concept of CSA were taking it for granted that with the present work load and overcrowded classrooms, one could not use this approach no matter how good it is.

The lecturers who appreciated the approach saw its advantages for the students as well. They said they found it useful for the learners to know what is expected of them. Indeed, on this point the lecturers criticised the present study for not allowing the students to know what it was in their performance that was being assessed. Since this point was raised in colleges only after the administration of the CSA tests, it was not possible to alter the strategy at that stage. The lecturers said that in the present study the researcher is assessing what the students normally do in their routine practical work rather than assessing their best capabilities. They argued that the students have the capabilities and if they knew what is expected from them they would definitely show it in their assessed performance. They felt if they do not reach the level of competency, which in fact the lecturers themselves were setting in this study, it would be because the students do not know the key of assessment not that they cannot do better. The overall ideas of using clear guidelines for assessment work was found useful though there was an awareness that it would likely entail the lecturers in extra work. However, they show that the approach had advantages over practical examination in that it overcomes the opportunity for unfair marking that they felt existed in the present system. Their critisism and reservations about the approach suggest that they had not quite fully absorbed the essential nature of criterion-referenced assessments as against norm-referenced assessments.

The interest which lecturers showed in setting of criteria, and their judgements of what would be the most appropriate criteria for assessment, suggests that if the lecturers were required to use this approach in their classes, they would find it interesting and helpful to their teaching and entirely manageable. There would, however, need to be training scheme for them to overcome the natural tendency to grade students in a norm—referenced fashion.

Lecturers' and students' views on individual CSA tasks were also obtained during discussions of the CSA tasks, while establishing criteria with the lecturers and, after the administration of CSA from talking with the students concerned.

The tasks on observation were said to be usual and routine work in biology practicals. The lecturers said it is relevant and appropriate for assessment of students' work in biology to include such tasks in assessment. At present, biology work is mainly based on observations, they commented, and biology students should be good at observations.

The tasks on making predictions were liked everywhere and were found interesting. These tasks lend themselves to a lot of discussions. The skill of prediction was said to be important and relevant to biology practical work.

The lecturers were not so sure if the skill of making graphs and reading and interpreting graphs are very relevant to the practical work in biology. Although, they said, a number of experiments involve graphing, and in the textbook there are occasions when a student is required to read and interpret the graphs, they felt it is mainly in physics where these abilities are developed. In this respect the lecturers found that CSA tasks for this particular skill were rather biased towards physics.

The tasks on measurement were found appropriate. However, the lecturers were concerned that imperfect measuring instruments may give a false judgement of students' performance and they were very careful to decide on suitable criteria of assessment for these tasks. The task of measuring the mass of a metal block particularly raised a lot of debate on what should be the criteria of assessment since the weighing balances were so imperfect. Secondly, the lecturers pointed out that in biology practical work students are rarely asked to use a weighing balance; it is mainly in chemistry practicals where students need to make a lot of use of weighing balances. The tasks on the measurement of volume using measuring cylinders, and the measurement of temperature using a clinical thermometer were judged to be appropriate for the assessment of biology practical work since both these items of equipment are used in biology practical work.

On the whole the CSA tasks were liked by the lecturers in the colleges and were said to be appropriate for making judgements on students' work and abilities. However, it was felt that the criterion-sampling approach was a rather lengthy process in their circumstances.

6.42 Students' views

The students found CSA tasks interesting and challenging. However, they did not like the task on drawing graphs. They said it is tedious and boring. It was also reported, in all colleges, that in biology there is very little work on drawing graphs and on those occasions where they are required to draw a graph the lecturers give full instructions on the method of drawing it. They, the students, do not need to decide which variables should be on the x axis and which one should be on the y axis. In one BSCS-user Degree college the girls found this task very challenging, and they did not achieve the level of competency.

The tasks on observation were said by students to be normal routine work in biology. They said that in science subjects biology is one of the subjects which helps them to develop the ability to make observations.

The tasks on taking measurements of mass, volume and temperature were also found challenging. In these tasks we knew, the students said, you are looking for accuracy in measurement so we used our best abilities. Students also said that if the criteria had been shown to them before performing the task they would have achieved the maximum score. They said they have performed these tasks as they normally perform in their routine practical work in biology.

The tasks on making predictions they said they found very interesting and students discussed all possibilities which could be considered in making predictions on the occasion. They said that in our routine work usually we know the results of experiments beforehand and it is more like puppet work, you do what you are asked to do. In this case, they added, it is fun to think of the possible results.

With the exception of the tasks on making graphs students found CSA tasks interesting, and challenging and relevant to their work in biology.

The CSA tasks took four hours, including the short break for lunch during which the students were given some snacks in the laboratory, at their seats. The students were critical of the duration of the CSA assessment and of the fact that it involved different activities and some complained that they had to divert their thinking in many directions. The students found CSA tasks lengthy, particularly graphing and reading and interpretation of graphs, but they did not find it tiring.

On the whole CSA tasks were liked in most of the colleges both by the lecturers and by the students and both groups found it an easy way of doing practical work and assessing it. The students commented that the key (criteria) could be very helpful to them in their work as it provided guidelines. They appreciated the fact that such lists amounted to a description of good scientific practice.

From these discussions it appears that if carefully used, criterion-referenced assessment, and in particular the criterion-referenced approach to it could be a means of overcoming many problems in practical work which the students and lecturers of Intermediate biology in Pakistan face at present.

CHAPTER 7

CONCLUSION

There has been a considerable degree of emphasis in Pakistan curricula on teaching science in such a way as to instil in students' inquiry skills and scientific attitudes. Educational conferences held at different times, the five-year- plan programmes and the Policy Statements all point in the same direction. One of the major steps in this direction was the adoption of inquiry-based BSCS materials, 'An Inquiry into Life', (Yellow Version) as the text materials for biology students for their Intermediate biology course. These materials have been in use in Pakistan for the Intermediate biology course for the last one and a half decades. The question that was addressed in this study was to what extent did the Intermediate biology course focus upon and generate inquiry skills in students taking this course.

The present study has revealed that the 1968 edition of this book provides ample opportunity for use of discrete science process skills by the students but very rarely provides an opportunity for higher-level, open- ended, inquiry investigations. Most of the investigations are at what has been termed Level One of inquiry, that is, both the problem and the method for tackling the problem are given. Even so, the majority of the lecturers prefer comparable materials for the Intermediate biology course that have been written by Pakistani writers (EPB materials). Analysis of these materials has revealed that they are written such as to exclude almost every opportunity for practising process skills. Almost all the investigations are presented in a way that are at the Level Zero of inquiry. That is, the problem and the methods for investigating it are given but in addition the answer to the problem is also given. A majority of lecturers say they prefer these materials to the BSCS which in itself is an indication of their preference for expository, content-based, teaching and learning of Biology.

A minority of lecturers use the BSCS (Yellow Version, 1968 edition) materials and do not allow their students to use EPB materials. However, a comparison of the perceptions and priorities of the two groups of the lecturers has revealed that there is no evidence to suggest that the use of the BSCS materials has affected the lecturers' views and priorities concerning the purpose of practical work in Intermediate biology. Both the BSCS-user lecturers and EPB-user lecturers have been found to prefer content to process skills. While there are some variations of opinion concerning the purposes of practical work, there is no evidence to suggest that any one group of lecturers is more pro-inquiry, or favours science process skills, than another. Nor is there any indication that variables like gender, age, experience amongst lecturers or the type of college in which Intermediate biology is taught has any considerable effect on the perceptions and views of the lecturers regarding the purposes of practical work. If there is any difference in perceptions between any two groups it is only in the degree to which accent is placed upon content. For instance, Intermediate college lecturers are more pro-content than are the lecturers in Degree colleges. However, this difference does not suggest that Degree college lecturers give more importance to inquiry skills than do the Intermediate college lecturers.

The claimed use of BSCS materials does not seem to have affected the overall approach of the lecturers towards the purpose of practical work in biology. From their response in questionnaires and in interviews they still see it as just another way of learning and understanding factual knowledge.

These findings are congruent with findings elsewhere. For instance, in the three studies contracted by the National Science Foundation in 1976 it was found that inquiry is not perceived to be as important as curriculum developers thought, nor is it an efficient method for teaching science processes (Hurd et al (1980)).

The perceptions of the lecturers in Pakistan are reflected in their practices. The methods they use in conducting practical work in biology have been found to have a heavy accent on facts and procedures. Observation is the one process skill which is given any considerable attention in the practical work. In this respect the practices of the lecturers at BSCS- user college are, once again, not markedly different from the practices of lecturers at EPB-user colleges.

The findings show that both groups of lecturers give most attention to facts and procedures and, with the exception of the skill of observation, they give very little importance in their practices to other science process skills.

Lecturers' perceptions and practices are congruent with each other, and their priorities have been found to be much the same as their practices. Indeed they often justify their preference for EPB materials on the grounds that they are more suitable for their needs.

In the present study it was found that lecturers held a strong conviction that BSCS materials are worthless for the needs of Pakistani students and they justified their views with four main reasons.

Firstly, these materials were written for an American culture and environment and for American students; most of the live materials used in the laboratory investigations are specific to America. The analysis of the BSCS Practical Guide has revealed that there is no evidence to justify this conviction, nor, in EPB materials is there any instance of an animal or a plant species having been replaced by another species or kind specific to and available in Pakistan. So there is no evidence in support of lecturers' views on this point.

Secondly, they claim that BSCS investigations involve equipment which is not available in Pakistan colleges and that BSCS investigations are too lengthy to be conducted in Pakistan with the limited time available. On this point there is some evidence in support of this conviction. Forty six experiments in the BSCS Practical Guide (Yellow Version) are the experiments that have been specified in the syllabus for the Intermediate biology course. Analysis of these 46 experiments has revealed that forty per cent of them cannot be performed in the colleges in Pakistan because of a lack of equipment and/or because of time limitation. Five investigations out of 46 involve sophisticated equipment (according to standards of laboratories in Pakistan) and require more than one laboratory period (that is, more than ninety minutes). Here again there is evidence that these are limiting factors and are frustrating both to the students and to the lecturers.

Thirdly, there is a widely held conviction that the cause of the inability to conduct investigations is overcrowding in the laboratory. There is no evidence to suggest that the colleges are deficient in biology laboratories. Overcrowding in many colleges seems to be unnecessary since the laboratories that have overcrowded classes were found not to be extensively used.

The fourth justification made by lecturers for them not using the BSCS practical guide as such was that the examination system does not require the process abilities and skills which were pursued in this study. On this point the lecturers do seem to be correct and their remarks justified. Information collected from both examiners and paper setters suggests that the practical examination in its present form is just another way of assessing recall and factual knowledge rather than students skills in doing a scientific investigation. The examination is a factor which others have also found to be a constraint acting against the achievement of desired outcomes. For instance, studies carried out by Nicodemus (1977), Schools' Council (1969) and more recently as pointed out by Dr. Michael Kingdon in a lecture delivered in the University of Keele, 1987, analysis of practical examination papers has revealed that little weighting is given to science process skills. There is a heavy coverage of content, and practical examination tests are more concerned with factual knowledge and memory than they are with process skills (Kingdon, M. (1987)).

In the present study, a comparison of the lecturers' views with those of the students revealed that there is a considerable degree of consistency between the views held by these two groups. The lecturers' perceptions appear to be transmitted to their students.

Students value their practical work more for learning content and understanding theory than for attitudes and behaviours conducive to learning science process skills. It is strange that the students at BSCS-user colleges value their practical more for learning facts than for understanding theory. Both groups of students, that is, those in EPB-user colleges and those in BSCS- user colleges feel that the practical examination is a test of memory.

Even though the accent in practical work is on content and factual knowledge a number of students, when tested with criterion-reference tasks for their competence in the intellectual process skills of science, were found to be competent in a number of these skills. Not surprisingly many students reach the level of competency in observation, for observation was one of the process skills the lecturers and students rated in their priorities for practical work. The students were even better with measurement in that a greater number of students reached the level of competency in measurement than achieved competency in observation, but when it comes to the higher-level intellectual process skills, such as predicting and interpreting, few students attained competency. No evidence was found that the type of college has any bearing on the development of skills, nor is there any evidence that the practical book has any bearing either.

It would seem that the lack of process-based skills amongst students at the Intermediate stage in biology in Pakistan is due in large measure to the form of the practical examination, for this, directs the attention of lecturers and students. On the lecturers own admission the examination does not require these process skills so these skills are not given attention.

In America, and in Britain, there is a considerable movement towards examination reforms in the sciences at the Secondary-school level which has at its heart the teaching of science process skills. Previous efforts to change the examination system has done little to affect the teaching and learning methods in favour of the science process skills. These recent developments reveal a shift from norm-referenced testing to criterion-referenced assessment, particularly for the assessment of practical work. The Coordinated Science Project (formerly known as the Suffolk Science Project) and the Warwick Process Science Project are but two of the recent programmes in Britain which have used criterion-referenced assessment to assess science process skills and the new GCSE examination for 16 year olds in Britain, in which its pupils graduate for the first time in 1988, has in the sciences including biology, up to 20% of the final marks allocated to the assessment of practical skills. It is laid down as a requirement that these marks are to be allocated on the basis of criterion-referenced assessments of pupils and these assessments are to be made by the teachers. The criteria are indicated in the Policy Statement (DES (1985a)) and given in detail in the National Critera for Science and for Biology (DES (1985b)). Those for the various performance levels are written in detail in the sciences syllabuses, including the biology syllabuses, that have been developed by the five examination boards in England and Wales. Indeed syllabuses are required to have such details if they are to be approved by the Secondary Examination Council. The GCSE certificate is available only to pupils who have studied an approved syllabus.

Even though the scheme is new there is evidence from many sources that leads one confidently to expect that such an assessment scheme is having the desired effect, namely that it does cause the pupils to develop science process skills. This is said to be the case by teachers at meetings and is volunteered on the basis of their own experience. It is also reported from such research as has been completed to date (for example that of Riskowitz (1986)), and from others including HMI who have reviewed its effects on both teachers and pupils for the Coordinated Science Project formerly known as Suffolk Science (Dr. Dudley (1987) private communication). It has also been found that both the teachers and the pupils like their science subjects and are enthusiastic about the practical work and this approach to its assessment (ibid.).

In the present study criterion-referenced tasks were used to gauge the students' competency in the process skills of science. A method was devised to establish what practical skills, in the lecturers' opinions, were their Intermediate biology students best at performing. They made their choices from a list of 25 skills that had been derived from the literature, and a natural cluster of 8 skills emerged these being the practical skills lecturers felt their students were most able to perform.

These eight skills were namely:

1. Observation
2. Classification
3. Measurement
4. Prediction
5. Handling apparatus
6. Making graphs
7. Interpreting and reading graphs
8. Selecting apparatus for experiment

From these a random sample of six skills was obtained and criterion-sampling assessment tasks relating to these six were developed and administered to the students. Despite the fact that these were skills that the lecturers themselves consider to be the strongest skills of their students, not all students were found to reach the level for competency, even for the skill of making observations which was the skill most highly rated by lecturers and the one most frequently mentioned in the interviews.

Lecturers and students address themselves very closely to the requirements of the practical examination and its assessment. The present system does not noticeably develop science process skills even amongst students for whom the BSCS textbook and practical guide are used as the official texts for the course.

However, the students and their lecturers responded enthusiastically to the criterion-referenced approach to the assessment of practical work and both are confident, in the light of their experience of it, that if told the criteria students will develop the performances to meet them.

Pupils studying GCSE science courses in Britain, including Biology courses, are also enthusiastic about this way of assessing their practical work and favour it, and there is growing evidence that it is generating science process skills amongst these pupils.

Since the criteria are essentially precise descriptions of good scientific practice and since students and lecturers in Pakistan are so positively in favour of it, then there is reason to believe a criterion-referenced approach to the assessment of practical work would cause Intermediate biology students to develop the science process skills. Intermediate biology students and their lecturers see criterion-referenced assessment as a means of generating the very science process skills that the Pakistan Policy Statement (1979) so desires.

This present study has shown that the use of an inquiry-based text book and practical guide itself has not noticeably promoted science process skills, that competency in these skills is not shown by all Intermediate biology students in Pakistan, that the students and their lecturers are favourably inclined towards criterion-referenced assessments of practical skills and that both students and lecturers feel sure of its positive effect in developing science process skills. It remains to be seen, however, whether, as seems likely on the evidence available at present, criterion-referenced assessments really do lead to the development of science process skills amongst Intermediate biology students in Pakistan.

APPENDICES FOR CHAPTER 4

APPENDIX 4.1

LIST OF EXPERIMENTS INCLUDED IN THE SYLLABUS OF BIOLOGY COURSE

1.0. The compound microscope-a scientific tool

2.0. Measuring the invisible

3.0. Life from non-life

4.0. Cells of living plants

5.0. Cells from you and frogs

6.0. Oxidation reduction in living cells

7.0. The closed box mystery

8.0. Mitosis and genetic continuity

9.0. Microbiological techniques

10.0. Distribution of micro-organisms

11.0. Staining and observing Bacterial cells

12.0. War on Bacteria

13.0. Fungus among us

14.0. Alternation of generations

15.0. A primitive vascular plant

16.0. The importance of seeds

17.0. Leaf structure and function

18.0. The pigments in leaf

19.0. Light and leaves

20.0 Plants and air

21.0. The gateway into a leaf

22.0. Roots

23.0. Transpiration in plants

24.0. Flowers

25.0. A simple key to flowering plants

26.0. From seed to seedling

27.0. Plant reactions to environment

CONT'D

28.0. Plants or animals

29.0. Structure and function in Paramecium

30.0. Locomotion of Paramecium

31.0. Animal classification

32.0. Two ways of life

33.0. Animals with jointed appendages

34.0. Form and function in the frog

35.0. Protein digestion

36.0. A living Invertebrate heart

37.0. Capillary circulation

38.0. Regulation of your breathing rate

39.0. Water balance

40.0. Sense reception and the nervous system

41.0 Control of muscle contraction .

42.0. Looking inside a contracting muscle

43.0. Effect of reproductive hormone

44.0. Reproduction and development in the frog

45.0. How does an egg form a chicken

46.0. Biological succession

APPENDIX 4.2

TABLE 4: Students grades in Secondary School Certificate Examination for Students in EPB User Colleges. The Number Given under Each Subject is the Number of Students (n=189) (Record of 14 Students not available)

Grades	Marks	English	Urdu	Biology	Chemistry	Physics	Mathematics	Pak.Studies	Is. Studies
A+	80% & Above	71 (38)	9 (4)	27 (14)	20 (11)	22 (11)	48 (25)	6 (3)	26 (14)
A	70% - 79%	52 (27)	46 (24)	61 (34)	31 (16)	35 (18)	26 (14)	25 (13)	45 (23)
B	60% - 69%	44 (23)	93 (49)	53 (28)	47 (25)	45 (23)	37 (20)	59 (31)	63 (33)
C	50% - 59%	15 (7)	27 (14)	31 (16)	46 (24)	44 (23)	36 (19)	62 (32)	39 (20)
D	40% - 49%	5 (2)	10 (5)	14 (7)	36 (19)	28 (14)	19 (10)	26 (14)	15 (7.9)
E	33% - 39%	2 (1)	3 (1)	3 (2)	7 (3)	12 (6)	12 (6)	10 (5)	1 (0.5)
F	Fail	0 (0)	1 (0.5)	0	2 (1)	3 (1)	11 (5)	1 (0.5)	0

4.2

APPENDIX 4·3

Students Grades in Secondary School Certificate Examination for Students in BSCs User Colleges n=76. The number given under each subject is the number of students.

Grades	Marks	English	Urdu	Biology	Chemistry	Physics	Mathematics	Pak. Studies	Is. Studies
A+	80% & Above	44 (64)	14 (21)	32 (47)	24 (35)	24 (35)	44 (84)	8 (12)	24 (35)
A	70% - 79%	9 (13)	32 (47)	17 (25)	22 (32)	18 (27)	8 (12)	14 (21)	13 (19)
B	60% - 69%	7 (10)	16 (23)	8 (12)	5 (7)	10 (14)	4 (5)	30 (44)	22 (32)
C	50% - 59%	6 (8)	4 (6)	4 (6)	8 (12)	7 (10)	5 (7)	4 (6)	6 (8)
D	40% - 49%	2 (3)	2 (3)	3 (4)	2 (3)	4 (6)	2 (3)	5 (7)	3 (4)
E	33% - 39%	0 (0)	0 (0)	4 (6)	3 (4)	3 (4)	4 (6)	7 (10)	0 (0)
F	Failed	0 (0)	0 (0)	0	4 (5)	2 (3)	1 (1)	0 (0)	0 (0)
Senior Cambridges		6	6	6	6	6	6	6	6
No record		2	2	2	2	2	2	2	2

4.3

APPENDICES FOR CHAPTER 5

University of Keele

Keele, Staffordshire, ST5 5BG

Telephone: Newcastle (Staffs) (0782) 621111
Telex: 36113 UNKLIB G

Department of Education

QR/PH

Dear Madam/Sir

I am a lecturer of Zoology at Allama Iqbal Open University, Islamabad, at present studying for a higher degree by research in the Department of Education, University of Keele, United Kingdom. Dr Brian Dudley, an eminent educationalist and also a biologist, is my supervisor. We are evaluating the biology curriculum of FSc in use in Pakistan, particularly its practical component.

As you are aware a major effort is being made to further improve science teaching in Pakistan and for this purpose the revision of science curricula has been started. Often these pay special attention to the practical component of science education. The present study, therefore, aims to collect and make available information about the practical work of the FSc as done at present.

It is important that we collect authentic and reliable information about the practical work done in colleges at FSc level and so I am writing to you for your help. We would like you to complete and return the enclosed questionnaire.

We assure you that all the information you furnish will be treated completely confidentially and it will be used only for this study.

We do hope you can spare some of your precious time to fill in and return the enclosed questionnaire and we include a stamped addressed envelope for your convenience.

We would be deeply grateful for your help and cooperation. An early reply would be greatly appreciated.

Yours sincerely

Rifat

Qudsia Rifat

Enc

THIS QUESTIONNAIRE IS IN FOUR SECTIONS, A, B, C, AND D. PLEASE READ THE INSTRUCTIONS GIVEN AT THE START OF EACH SECTION AND FILL IN THE QUESTIONNAIRE ACCORDINGLY

IF ANY QUESTION, STATEMENT OR TERM IS NOT CLEAR TO YOU PLEASE DRAW A CIRCLE AROUND ITS NUMBER.

PLEASE DO FEEL FREE TO ADD YOUR COMMENTS OR OPINIONS, RELEVANT TO THIS INVESTIGATION, ON THE EXTRA SHEET PROVIDED.

WE THANK YOU FOR YOUR HELP.

****

SECTION A: GENERAL INFORMATION

In this part of the questionnaire you are asked to provide some general information which will be used to classify the results. You do not need to give your name, though if you did it would be helpful. All responses would be treated as confidential.

Please put a tick in the box as appropriate.

1. Type of institution you teach in:

(a) Single Sex ☐ Co educational ☐

(b) School with F.Sc classes ☐ College with F.Sc Classes Only. ☐ Degree College with F.Sc Classes. ☐

2. Your age group:

25 and below ☐ 26 to 30 ☐ 31 to 35 ☐

36 to 40 ☐ above 40 ☐

3. Sex: Female ☐ Male ☐

CONT'D...

Section A.

4. Qualifications:

M.Sc in Botany ☐ Biology ☐ Zoology ☐

5. The year you passed M.Sc: 19____.

6. Did you carry out any independent research work in M.Sc?

Yes ☐ No ☐

7. Other qualifications: (please tick the box/boxes as appropriate)

None ☐ B.Ed. ☐ M.Ed. ☐ M.Phil ☐ Ph.D. ☐

8. In the case of M.Phil and Ph.D please indicate the area of specialisation:

____

9. Any other qualifications:

____

10. Your experience of teaching to F.Sc classes:

0 to 10 years ☐ 11 to 15 years ☐ More than 15 years ☐

11. Do you teach the whole course of F.Sc biology, i.e. both theory and practical?

Yes ☐ No ☐

If 'NO' please indicate the parts you teach:

CONT'D...

SECTION B: AIMS OF PRACTICAL WORK IN BIOLOGY

Below is a list of aims of practical work in biology. Plase read EACH aim and for EACH one indicate how important you think it is for F.Sc biology students. Indicate your opinion by drawing a circle around the appropriate number. Use the following key to give your opinion.

1. Completely Unimportant 2. Not Important 3. Important

4. Very Important 5. Essential

	Completely Unimportant	Not Important	Important	Very Important	Essential
1. As a creative activity (To encourage imagination, initiative, inventiveness).	1	2	3	4	5
2. To make biological phenomena more real through actual experience,	1	2	3	4	5
3. To give training in problem solving (i.e. to identify problems in new situations to make and test hypothesis, obtain necessary data and to draw conclusions).	1	2	3	4	5
4. To indicate relevance and application of knowledge of biology in real life.	1	2	3	4	5
5. To help remember facts and principles.	1	2	3	4	5
6. To encourage simple commonsense scientific methods of thought (to develop the habit of trying things out, to observe and record data accurately, to be willing to change opinion when evidence gives cause, to delay making conclusions).	1	2	3	4	5

CONT'D ...

Section B.

	Completely Unimportant	Not Important	Important	Very Important	Essential
7. To encourage accurate and careful observations.	1	2	3	4	5
8. To be an integral part of finding facts and arriving at principals.	1	2	3	4	5
9. To develop an ability to understand and carry out instructions.	1	2	3	4	5
10. To clarify theoretical work so as to aid in understanding.	1	2	3	4	5
11. To develop personal characteristics such as independent thought, resourcefulness, confidence, reliability and responsibility.	1	2	3	4	5
12. To arouse and maintain interest.	1	2	3	4	5
13. To develop an ability to convey knowledge of biology to others by speech or writing.	1	2	3	4	5
14. To develop certain disciplined attitudes,	1	2	3	4	5
15. To verify facts and principles already taught.	1	2	3	4	5

Cont'd ....

Section B.

	Completely Unimportant	Not Important	Important	Very Important	Essential
16. To develop an ability to handle apparatus skilfully.	1	2	3	4	5
17. To develop ability to cooperate with others.	1	2	3	4	5
18. To develop a critical attitude.	1	2	3	4	5
19. To give an opportunity to practice standard techniques and procedures.	1	2	3	4	5
20. To prepare the student for practical examination.	1	2	3	4	5

Are there any other aims which you think are essential for a biology student?
If so please indicate:

SECTION C: SKILLS INVOLVED IN THE PRACTICAL WORK IN BIOLOGY

In this part of the questionnaire you are asked to compare YOUR F.Sc biology students with the IDEAL F.Sc biology student on a number of skills which are considered by science educators to be associated with practical work in biology.

Below and on the following pages you will find a list of these skills. We would like you to read the statements describing each skill and then decide if an IDEAL F.Sc biology student was in your college in the SAME class as you teach what marks out of ten you think you would give him or her if a test was given on each of the following skills.

After you have rated the ideal student, think about your OWN F.Sc. biology students and decide what marks you THINK the majority of your students would get in the same test.

PLEASE RATE BOTH IDEAL AND REAL STUDENTS ON EACH SKILL:

1. Able to plan and design simple experiments.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
2. Able to identify problems to be studied.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
3. Able to state a problem in such a way that it can be studied.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
4. Able to identify the hypothesis being studied.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
5. Able to formulate an hypothesis.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
6. Able to predict probable results of the experiment.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
7. Able to identify variables.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10

CONT'D ...

Section C:

Item											
8. Able to choose the appropriate variables for study.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
9. Able to design methods of data collection (measurement, observation and other procedures).	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
10. Able to select materials and equipment for the experiment.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
11. Able to carry out experiment properly.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
12. Able to make accurate and complete observations.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
13. Able to take measurements accurately.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
14. Able to classify specimens using keys.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
15. Able to use apparatus skilfully.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
16. Able to record observations and measurements accurately.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
17. Able to make proper use of experimental control.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
18. Able to identify experimental control.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10

CONT'D ...

Section C:

19. Able to analyse and interpret data.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
20. Able to represent data in the form of chart, graph or table.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	88	9	10
21. Able to interpret graph, chart or table.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
22. Able to infer accurately from data.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
23. Able to draw general conclusions from data.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
24. Able to verify results.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10
25. Able to apply the knowledge gained from data to new situation.	Ideal	1	2	3	4	5	6	7	8	9	10
	Real	1	2	3	4	5	6	7	8	9	10

SECTION D: MISCELLANEOUS

Do you think the practical work in F.Sc carries an adequate percentage of the total marks?

Yes ☐ No ☐

If 'NO' please specify your reason:

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Do you wish to make any changes in the practical syllabus of F.Sc?

Yes ☐ No ☐

If 'YES' what changes would you like to suggest. You may write in Urdu if you wish.

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Please add here and continue overleaf if necessary any other comments which you think are related to this inquiry. Please also comment on the questionnaire if you wish.

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Telex: 36113 UNKLIB G

Department of Education

عزیز طالبہ / طالب علم

آج ہم آپ کو ایک سوالنامہ پر کرنے کی زحمت دے رہے ہیں۔ یہ سوالنامہ آپ کے بائیولوجی کے نصاب کے بارے میں چند معلومات حاصل کرنے کے لیے مرتب کیا گیا ہے۔ شاید آپ کو یہ تو معلوم ہی ہوگا کہ ہمارے ملک میں سائنس کی تعلیم کو بہتر بنانے کے لیے سائنس کے موجودہ نصاب کو دہرایا یا تبدیل کیا جا رہا ہے۔ اس سکیم میں آپکا بائیولوجی کا کورس بھی شامل ہے۔

کوئی بھی نیا کورس لکھنے کے لیے یہ ضروری ہوتا ہے کہ لکھنے والوں کو پرانے کورس کی خوبیوں اور خامیوں دونوں کا علم ہو۔ تاکہ نئے کورس میں جہاں پرانے کورس کی خامیوں کا اعادہ نہ ہو وہاں اگر پرانے کورس میں کوئی خوبی ہے تو اسے برقرار رکھا جائے۔ ہمارے سوالنامہ کا بنیادی مقصد آپ کے بائیولوجی کے کورس کے بارے میں اسی قسم کی معلومات جمع کرنا ہے۔

میں علامہ اقبال اوپن یونیورسٹی میں زوالوجی کی لیکچرر کے طور پر تعینات ہوں۔ آجکل برطانیہ کی کیل یونیورسٹی میں مزید تعلیم حاصل کر رہی ہوں۔ ڈاکٹر برائن ڈڈلے جو کہ ایک بائیولوجسٹ ہونے کے ساتھ ساتھ ماہر تعلیم بھی ہیں میرے تحقیقی کام میں میری مدد اور رہنمائی کر رہے ہیں۔

ہماری تحقیق کے لیے یہ بہت ضروری ہے کہ ہم صحیح معلومات حاصل کریں۔ یہ معلومات ایک طرف تو ہمارے تحقیقی کام کی تکمیل کے لیے اہم ہیں دوسری طرف اگر ہمیں صحیح معلومات حاصل ہو جاتی ہیں تو یہ آپکا نیا کورس لکھنے والوں کے لیے بھی معاون ثابت ہوں گی۔ ہم آپ کے مشکور ہوں گے اگر آپ ہمیں یہ معلومات فراہم کریں گے۔

آپ چونکہ بائیولوجی پڑھ رہے ہیں اس لیے جتنی درست معلومات آپ فراہم کر سکتے ہیں شاید کہیں اور سے حاصل نہ ہو سکیں۔ اس سے پیشتر کہ آپ سوالنامہ پر کرنا شروع کریں ہم چند باتوں کی وضاحت کر دیں تاکہ آپ سوالنامہ بلا جھجک اور مکمل آزادی سے پر کریں۔

- پہلی اہم بات یہ ہے کہ اس سوالنامہ سے حاصل ہونے والی تمام تر معلومات کو صرف اس تحقیق کے لیے استعمال کیا جائیگا۔ آپکا نام وغیرہ صرف سوالناموں کی جماعت بندی کے لیے درکار ہے۔ آپکی فراہم کردہ تمام تر معلومات کو صیغہ راز میں رکھا جائیگا آپ اسے حلفیہ بیان سمجھ سکتے ہیں۔
- دوسری اہم بات یہ ہے کہ ممکن ہے سوالات کی نوعیت سے آپ کو محسوس ہو کہ آپکا یا خدانخواستہ آپ کے اساتذہ کا امتحان ہے تو یقین رکھیئے ایسا کوئی مقصد ہرگز نہیں ہے۔ مقصد صرف موجودہ کورس کے بارے میں معلومات جمع کرنا ہے۔
- تیسری اور شاید اہم ترین بات یہ ہے کہ چونکہ یہ سوالنامہ کسی کا امتحان لینے کے لیے نہیں ہے لہذا کسی بھی سوال کا کوئی درست یا غلط جواب نہیں ہے۔ جو بھی معلومات آپ درست سمجھتے ہیں یا جو بھی آپ کی ذاتی رائے ہے وہی ان سوالوں کا درست جواب ہے۔ ہمیں صرف آپ کی ذاتی رائے چاہیئے ہے۔

ہم آپ کے اس تعاون کے لیے آپ کے ممنون و مشکور ہوں گے۔

Rifat   قدسیہ رفعت

B. Dudley.   ڈاکٹر برائن ڈڈلے

STUDENT'S QUESTIONNAIRE

THIS QUESTIONNAIRE IS IN '3' SECTIONS - A, B, AND C . PLEASE READ THE INSTRUCTIONS GIVEN AT THE START OF EACH SECTION AND FILL IN THE QUESTIONNAIRE ACCORDINGLY.

یہ سوالنامہ تین حصوں اے، بی اور سی پر مشتمل ہے - مہربانی فرما کر ہر حصہ کی
ابتداء میں درج کردہ ہدایات کا بغور مطالعہ کیجئے اور ان کے مطابق سوالنامہ پر کریں -

WE WOULD LIKE TO REMIND YOU THAT THERE IS NO RIGHT OR WRONG ANSWER TO ANY QUESTION. PLEASE GIVE THE INFORMATION WHICH YOU THINK IS RIGHT. WE NEED YOUR OWN PERSONAL OPINION SO DO NOT CONSULT YOUR FRIENDS.

یاد رہے کہ کسی بھی سوال کا کوئی غلط یا درست جواب نہیں ہے - آپ جو بھی معلومات درست سمجھتے ہیں
صرف وہی تحریر کیجئے - ہمیں صرف آپ کی ذاتی رائے کی ضرورت ہے لہذا دوستوں سے مشورہ کرکے جواب نہ لکھیئے -

PLEASE PUT A TICK IN THE BOX OR BOXES AS APPROPRIATE. FOR EXAMPLE IF YOU ARE STUDYING IN A DEGREE COLLEGE FOR BOYS YOU WILL ANSWER QUESTION NO. 1, AS FOLLOWS:

اپنے جواب کی نشاندہی کے لیے مناسب خانے یا خانوں میں ٹھیک کا نشان لگائیے مثلاً
اگر آپ لڑکوں کے ڈگری کالج میں زیر تعلیم ہیں تو اس صورت میں سوال نمبر 1 کا جواب آپ ذیل میں
دیئے گئے طریقے کے مطابق دیں گے:

1. Type of the institution you are studying in:

(a)	Girls' college	☐	Boys' college	✓	Co-educational	☐
(b)	College with F.Sc classes only	☐	Degree college F.Sc classes	✓	School with F.Sc classes	☐

WE THANK YOU FOR YOUR HELP.

تعاون کے لیے شکریہ -

....

NAME: ______________________ DATE: ______________

ROLL NO: ______________________

1. Type of institution you are studying in: آپ کس ادارہ میں زیر تعلیم ہیں

   (a) Girls' College ☐ Boys' College ☐ Co-educational ☐

   (b) College with F.Sc classes Only. ☐ Degree College with F.Sc ☐ School with F.Sc. classes ☐

2. Which year of F.Sc are you in: آپ ایف ایس سی کے کس سال میں ہیں

   First year ☐ Second year ☐

3. Your Age: ______________ آپ کی عمر کیا ہے ۔

4. Sex: صنف Female ☐ Male ☐

5. School you last attended: ۔ آپ نے میٹرک کس سکول سے کیا تھا

   Govt. School ☐ Convent School ☐ Public School ☐ Private School ☐

   If you did your Matric as a private candidate please tick the box ☐
   اگر آپ نے میٹرک بطور پرائیویٹ امیدوار کیا تھا تو نشاندہی کیجئے ۔

6. Please indicate the subjects you studied in Matric, also give the marks you obtained in each subject.

SUBJECTS	MARKS OBTAINED	TOTAL MARKS
English		
Urdu		
Social Studies		
Islamic Studies		
Biology		
Chemistry		
Physics		
Maths		
Others		

7. Medium of instruction in Matric: میٹرک میں آپ کو کس زبان میں پڑھایا جاتا تھا

Urdu ☐ English ☐

8. Did you yourself carry out any practical work in biology in Matric:

کیا آپ نے میٹرک میں بائیولوجی کے مضمون میں تجربات کئے تھے۔

Yes ☐ No ☐

9. Group of subjects you are studying in F.Sc:

ایف ایس سی میں آپ نے سائنس کا کون سا گروپ اختیار کیا ہے۔

Pre Medical ☐ General Science ☐

10. Please indicate the marks you obtained in annual examinations of first year and if you are in first year, then indicate the marks you obtained in any end of term examination.

آپ نے فرسٹ ایئر کے سالانہ امتحان میں دیئے گئے ہر مضمون میں کتنے نمبر حاصل کئے تھے۔ اگر آپ ابھی فرسٹ ایئر میں ہی تو کسی سہ ماہی یا ششماہی امتحان میں حاصل کردہ نمبر درج کر دیجئے۔

SUBJECTS	MARKS			
	THEORY		PRACTICAL	
	Total	Obtained	Total	Obtain
English				
Urdu				
Pak-Studies				
Islamic Studies				
Biology				
Chemistry				
Physics				
Any Other				

11. Have you done any practical work in biology in F.Sc. کیا آپ نے ایف ایس سی میں اب تک بائیولوجی میں کوئی پریکٹیکل کئے ہیں۔

Yes ☐ No ☐

12. Do you have the Students Practical Guide: 'An Inquiry Into Life'

کیا آپ کے پاس مندرجہ بالا پریکٹیکل گائیڈ ہے۔

Yes ☐ No ☐

CONT'D....

Section B.

In this section you are asked to indicate how useful you find practical work in biology for EACH of the purposes listed below. Use the key given below to indicate your opinion. Draw a circle round the number which indicates your opinion.

سوالنامہ کے اس حصہ میں آپ ہمیں یہ بتائیں گے کہ الف ایس سی میں کروائے جانے والے تجربات کو آپ نے
ذیل میں درج ہر مقصد کے لیے کس حد تک مفید پایا۔ جواب دینے کے لیے درج ذیل Key استعمال کریں۔

1. = Very Useful (بہت مفید) 2. = Useful (مفید) 3. = Moderately Useful (مناسب حد تک مفید)

4. = Slightly Useful (قدرے مفید) 5. = Not At All Useful (بالکل مفید نہیں۔)

	Very Useful	Useful	Moderately Useful	Slightly Useful	Not at all Useful
1. To understand theory. تھیوری کے سمجھنے میں۔	1	2	3	4	5
2. To pass eximination. امتحان پاس کرنے کے لیے	1	2	3	4	5
3. To develop ability to make complete and correct observation. مکمل اور درست مشاہدات کرنے کی صلاحیت پیدا کرنے میں۔	1	2	3	4	5
4. To develop skill in using equipment. تجرباتی آلات وسامان استعمال کرنے کی صلاحیت پیدا کرنے میں	1	2	3	4	5
5. To maintain interest in biology. بائیولوجی کے مضمون میں دلچسپی برقرار رکھنے میں۔	1	2	3	4	5
6. To develop habit of independant thinking, self reliance and self confidence. آزادانہ سوچ، ذات پر انحصار کرنے، اور خود اعتمادی پیدا کرنے میں	1	2	3	4	5
7. To develop habit of critical thinking. تنقیدانہ طرز سوچ کی عادت ڈالنے میں۔	1	2	3	4	5
8. To remember facts and principals taught in theory. تھیوری میں پڑھائے گئے حقائق اصول یاد رکھنے میں۔	1	2	3	4	5

12. If you have the above mentioned practical guide, how often if at all do you do your practical work with its help?

اگر آپ کے پاس مندرجہ بالا پریکٹیکل گائیڈ ہے تو یہ بتائیے آپ اپنے تجربات میں اسے کتنا استعمال کرتے ہیں۔

Never ☐ Rarely ☐ Occasionally ☐ Often ☐

Always ☐

13. Please indicate the names of all other note books or practical guides which you use as text books for practical work in biology:

اگر آپ کورس کی لاگو کردہ پریکٹیکل گائیڈ کے علاوہ کوئی اور پریکٹیکل گائیڈ یا چھپی ہوئی نوٹ بک استعمال کرتے ہیں تو ان کا نام ذیل میں تحریر کریں۔

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SECTION C:

In this section we invite you to comment on your biology text books. Please write 100-150 words. If you have any other comments on your biology course, practical work or methods of teaching and examination please feel free to write. All information given by you will be treated as confidential.

سوالنامہ کے اس حصہ میں ہم نے آپ کو بائیولوجی کی نصابی کتابوں پر تبصرہ کرنے کی دعوت دی ہے ۔
مہربانی فرماکر سو سے ڈیڑھ سو الفاظ میں اپنی بائیولوجی کی نصابی کتب کے بارے میں آپ کی
جو رائے بھی ہو اسکا اظہار کیجئے ۔ اس کے علاوہ اگر آپ اپنے کورس، پریکٹیکل، طرز تدریس
یا امتحانات کے بارے میں بھی اگر رائے دینا چاہیں، یا تبصرہ و تنقید کرنا چاہیں تو بے حد شوق کیجئے ۔

COLLEGE ____________ TEACHER ____________ PERIOD ____________ DATE ____________

T Gvs S-b-s instr.	F1
T des obs. S shld mk	I4
T sys/ds noth in resp to SQ	J6
T des concl S shld mk	N11
T conduct demons	E6
T sits/lvs the lab	I7
T gvs dir ans to SQ	J4
T ask shw/wy a phe occurd	I3
T gvs statmnt of fct/princ	X
T ask S to desc an obj/phen	I2
T ask S to obs an obj/phen	I1
T ask S to org dta in gr/others	M1
T ask S to compre res of expt	M2
T dis poten'l prob in lab	F2
T mks stmnts of safe prec	F5
S mk their own obs	D6
S ask T for help with invst	L2
S seek info to confirm/ acq fct	E1
S seek guid when making infer	E3
T ask S to sugst furth invst	N9
T ask S to mke hypo	N3
T ask S to identi er/var	N4
T asks S to pdct	N5

5C

Categories Used in the Present Study

TEACHER'S STATEMENTS

- \- Teacher gives step by step instructions to perform experiment.
- \- Teacher describes observations students should make.
- \- Teacher gives statements of facts and principles
- \+ Teacher discuss potential problems in performance of experiment.
- \- Teacher describes the conclusions students should draw.
- \+ Teacher makes safety precautions.

TEACHER'S QUESTIONS AND DIRECTIVES

- \+ Teacher asks students to make an hypothesis.
- \+ Teacher asks students to observe an object or phenomena.
- \+ Teacher asks students to find the source of error or variability in data.
- \+ Teacher asks students to predict the results.
- \+ Teacher asks students to suggest further investigation.
- ± Teacher asks students to describe an object or phenomena
- \+ Teacher asks students to organise their data in chart, graph or summary form.
- \+ Teacher asks students to compare their results with each other.
- ± Teacher asks students why or how a phenomena occured.

TEACHER RESPONSE TO STUDENTS QUESTIONS

- \- Teacher says or does nothing in response to a students question.
- ∓ Teacher gives a direct answer to student's question.

TEACHER'S NON VERBAL BEHAVIOUR

- ∓ Teacher demonstrates the experiment.
- \- Teacher sits back or leave the lab.

STUDENTS BEHAVIOUR

- \+ Student make observations.
- ± Students refer to teacher to ask for help in investigation.
- ± Students refer to teacher to acquire or confirm a fact.
- \+ Students refer to teacher when making an inference.

BIOLOGY LABORATORY INVENTORY

College: EPBB [ ] BSCS [ ] Date: ______________

1. Type of College: Male [ ] Female [ ]
   Degree [ ] Intermediate [ ] School Based [ ]

2. Staff:

   (i) Number of biology lecturers ______

   (ii) Number of biology lecturers teaching F.Sc: First Year ______
   Second Year ______

   (iii) Number of laboratory assistants available for F.Sc ______

   (iv) Number of laboratory attendants available for F.Sc ______

3. Students:

   Number of students in F.Sc ______

   (i) Number of biology laboratories available for F.Sc ______

   (ii) A proper laboratory ______

   (iii) Laboratory in corner of room/corridor ______

4. Laboratory facilities available

   (i) Cupboards for glassware and specimens ______

   (ii) Shelves for specimens ______

5. TABLE SEE ATTACHED SHEET

6. Others [ ] Refrigerator [ ] Oven [ ]
   Pressure Cqoker [ ] Incubator [ ] Waterbath [ ]

CONT'D......

BIOLOGY LABORATORY INVENTORY

Year	Number of Students in Section	Number of Sitting Places in Lab.	Number of Microscopes in Lab.	Number of Water sinks	Number of Gas Taps	Number of Electricity Points	Number of Microscopes Binoculas
	1 2 3 4	1 2	1 2	1 2	1 2	1 2	1 2
1.							
2.							

5F

APPENDIX 5F

TABLE: Summary of Laboratory Load, Laboratory Capacity and Services and Facilities Available in EPB User Colleges.

Key: * 2 Laboratories for F.Sc.

College	No. of Students in Grades		Total No. of Students in XI & XII	No. of Students in one Practical Group		No. of Practical Groups in		No. of Laboratories Available
	XI	XII		XI	XII	XI	XII	
MBn	250	250	500	30	30	8	8	2
FVa	121	80	201	61	41	2	2	*1
MSz	120	80	200	60	40	2	2	1
FSd	90	50	140	30	25	3	2	*½
MSa	80	100	180	40	50	2	2	*½
FJm	71	41	112	36	21	2	2	*1
MAc	70	70	140	35	35	2	2	*1
FAc	40	35	75	40	35	1	1	*½
FGg	40	30	70	40	30	1	1	1
MDg	38	80	118	29	40	2	2	1
MJm	65	60	125	22	20	3	3	1
FMn	52	36	88	52	36	1	1	1
FK+	46	30	76	23	30	2	1	1
Mmn	20	10	30	20	10	1	1	1
Msz	7	6	13	7	6	1	1	1
MGn	6	6	12	6	6	1	1	1

APPENDIX 5F

TABLE: Summary of Laboratory Load, Laboratory Capacity and Services and Facilities Available in EPB User Colleges.

College	Proportion of Laboratory Units used Maximum 18	Laboratory Capacity XI	Laboratory Capacity XII	No. of Laboratory Assistants	No. of Laboratory Attendents	No. of Microscopes and Students in Grades XI		No. of Microscopes and Students in Grades XII	
MBn	88.88	A	A	½	½	1/1	1/1	1/1	1/1
FVa	33.33	C	C	½	½	3/1	3/1	2/1	2/1
MSz	44.44	C	B	1	2	5/1		3/1	
FSd	88.88	C	C	3/2	1	2/1		1/1	
MSa	88.88	C	C	2	1	1/1		2/1	
FJm	44.44	C	A	2	3/2	3/1	2/1	2/1	1/1
MAc	44.44	C	C	½	½	2/1	4/1	4/1	4/1
FAc	44.44	C	C	1/3	1/3	2/1		2/1	
FGg	22.22	C	C	1	1	1/1		1/1	
MDg	44.44	A	C	1	1	1/1		2/1	
MJm	66.66	B	B	1	1	2/1		2/1	
FMn	22.22	C	C	1/3	1	4/1		3/1	
FK+	33.33	C	C	1/3	1/3	1/1		1½/1	
Mmn	22.22	C	C	1/3	1/3	2/1		1/1	
MSz	22.22	A	A	1	1	1/1		1/1	
MGn	22.22	A	A	1/2	2/3	1/1		1/1	

APPENDIX 5F

Summary of Laboratory Load, Laboratory Capacity and Services and Facilities

College	Total No. of Students in Grades		Total in F.Sc	No. Of Students in one Group		No. of Practical Groups in Grades		No. of Laboratories for F.Sc.	Proportion of Laboratory Units Used by XI & XII Maximum - 18
	XI	XII	Total	XI	XII	XI	XII		
FL_2	300	260		75	65	4	4	1	88.88
MG_c	240	240	480	80	80	3	3	1	66.66
MF_c	160	150	310	40	25	4	6	2	55.55
FQ_y	134	130	274	67	65	2	2	½	88.88
FKd	80	75	155	27	25	3	3	1	66.66
MS_a	30	20	50	30	20	1	1	1	22.22

APPENDIX 5F

Summary of Laboratory Load, Laboratory Capacity and Services and Facilities (Continued)

College	Laboratory Capacity for Grades XI	XII	No. of Lecturers Total	No. of Assistants per Lab.	No. of Attendents Per Lab.	Ratio of Microscopes and Students in Grades XI		XII	
FL_2	A	A	17	2	2	1/1		1/1	
MG_c	A	A	12	3	2	2/1		2/1	
MF_c	A	A	8	1	1	2/1	2/1	2/1	2/1
FQ_y	C	C	4	3/2	1/2	3/1		3/1	
FKd	A	A	3	1/2	1/2	1/1	1/1	1/1	1/1
MS_a	C	C	1	1/3	1/3	1/1		1/1	

5F

APPENDIX 5G

RAW DATA

Lecturers code	Rating given to each aim																			
ZMD 1	4	4	4	3	4	4	5	5	5	4	4	3	3	4	4	4	4	3	3	5
ZMD 2	5	5	3	5	3	5	5	2	3	3	4	4	3	3	1	3	3	2	3	3
ZFD 3	5	3	4	5	5	4	5	3	3	3	3	4	3	5	4	5	4	4	4	3
BMD 4	4	5	5	4	4	4	4	5	4	4	5	4	4	5	5	3	3	5	4	5
BMD 5	5	5	5	2	3	2	3	3	3	2	3	3	2	3	2	3	3	2	3	3
BMD 6	3	3	1	1	3	1	3	1	1	3	1	3	1	1	3	3	3	1	1	3
ZMD 7	4	5	5	3	3	5	4	3	4	5	4	4	2	3	4	3	3	4	3	5
ZMD 8	3	4	2	3	3	2	3	2	5	5	4	4	3	2	3	5	2	2	2	2
ZMD 9	5	5	5	5	5	3	3	3	1	1	4	1	1	2	2	1	4	2	2	2
ZMD10	3	4	5	3	3	4	3	4	4	4	4	3	4	5	3	4	3	2	2	4
ZMD11	5	5	3	3	5	3	4	3	4	4	2	3	3	3	4	4	3	3	3	5
ZMD12	3	3	3	3	3	3	3	3	3	3	3	4	4	5	4	4	4	4	4	4
BFD13	5	5	4	4	4	4	4	3	4	4	3	3	3	3	4	4	3	2	4	4
ZFD14	5	5	3	1	4	4	4	1	3	3	3	2	1	4	3	4	4	3	1	4
ZFD15	5	5	2	5	4	5	5	1	2	5	3	5	3	5	4	3	4	3	1	3
ZFD16	4	4	3	4	4	4	5	4	4	4	3	4	4	3	5	5	5	3	4	5
BFI17	3	4	3	4	5	2	4	1	3	4	5	5	4	4	5	4	5	4	3	3
ZFI18	5	4	4	4	3	4	4	4	3	3	3	4	3	4	4	3	4	4	5	4

Cont'd......

Lecturers code	Rating given to each aim																			
BMD19	3	3	4	3	3	5	4	3	3	4	3	3	3	3	4	4	3	5	3	3
*BMD20	4	5	4	4	3	3	5	4	4	5	4	5	2	3	3	5	5	3	4	4
BMD21	4	4	3	5	4	3	4	3	4	4	4	4	5	4	4	4	5	5	4	4
ZMD22	3	3	3	4	4	4	3	3	4	5	5	3	5	4	3	5	3	4	4	4
ZMD23	3	5	3	4	4	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
ZFD24	3	4	3	5	4	2	5	4	5	5	5	4	4	3	2	3	4	3	3	3
BMI25	4	5	4	5	5	4	4	4	4	5	3	3	3	3	5	4	4	4	4	4
*BMI26	3	5	4	3	5	4	5	1	3	5	5	3	4	1	4	4	4	3	5	5
ZMI27	3	2	5	5	5	3	5	3	4	5	4	4	3	5	3	5	4	5	5	5
BFI28	4	5	4	4	5	5	5	4	4	4	4	5	3	3	4	4	5	4	5	4
BMD29	3	5	4	3	3	5	5	3	4	5	3	3	3	2	4	4	3	4	4	3
BMD30	4	4	5	4	5	5	4	4	4	4	5	5	4	5	5	5	5	4	5	5
ZMD31	3	4	3	4	4	5	4	3	5	4	4	3	3	1	3	4	3	4	3	5
ZMD32	5	3	3	4	2	2	3	2	3	4	5	2	3	3	3	4	1	4	3	2
BMI33	3	4	2	3	4	3	4	3	4	5	4	5	3	3	5	4	3	3	3	5
ZMI34	3	3	3	4	3	3	4	5	3	5	3	4	5	4	3	4	5	3	3	5
ZMI35	2	5	4	5	5	3	4	3	5	5	3	3	3	3	3	5	3	3	3	3
BMI36	2	3	4	4	5	4	3	2	3	4	4	3	2	4	3	4	5	3	3	4
ZFD37	3	2	3	1	2	4	4	1	5	2	5	1	4	5	5	5	3	2	1	5
BFD38	5	3	3	3	5	3	4	5	4	4	3	4	4	2	3	5	5	3	3	5

KEY
- BMD = Male lecturer with M.Sc in botany teaching in Degree college
- ZMD = Male lecturer with M.Sc in zoology teaching in Degree college
- BFD = Female lecturer with M.Sc in botany teaching in Degree college
- BZD = Female lecturer with M.Sc in zoology teaching in Degree college
- ZMI = Male lecturer with M.Sc in zoology teaching in Intermediate college
- BMI = Male lecturer with M.Sc in botany teaching in Intermediate college
- ZFI = Female lecturer with M.Sc in zoology teaching in Intermediate college
- BFI = Female lecturer with M.Sc in botany teaching in Intermediate college

* M.Sc in biology

APPENDIX 5H

Mid-rank mean scores drawn from rating given to the aims

Lecturers		Mid-rank mean values									
1	1	3.5	10.0	10.0	3.5	17.0	17.0	17.0	17.0	10.0	17.0
1	2	3.5	3.5	17.0	10.0	10.0	3.5	3.5	10.0	10.0	17.0
2	1	1.5	12.5	6.0	6.0	18.5	12.5	12.5	18.5	12.5	1.5
2	2	18.5	6.0	12.5	12.5	16.0	6.0	6.0	6.0	18.5	6.0
3	1	4.5	17.5	4.5	4.5	19.5	17.5	14.0	14.0	14.0	4.5
3	2	4.5	10.0	4.5	10.0	4.5	4.5	14.0	10.0	19.5	14.0
4	1	11.0	18.5	11.0	3.0	11.0	11.0	18.5	11.0	18.5	11.0
4	2	11.0	11.0	11.0	3.0	11.0	18.5	3.0	3.0	11.0	3.0
5	1	15.0	15.0	19.5	3.0	8.5	3.0	3.0	8.5	15.0	8.5
5	2	3.0	8.5	3.0	19.5	8.5	15.0	15.0	8.5	15.0	15.0
6	1	11.0	11.0	8.0	8.0	18.5	3.5	3.5	8.0	14.5	14.5
6	2	18.5	14.5	14.5	3.5	18 5	3.5	3.5	11.0	18.5	3.5
7	1	1.5	8.5	8.5	8.5	8.5	17.5	17.5	17.5	8.5	8.5
7	2	8.5	17.5	17.5	8.5	8.5	8.5	17.5	8.5	1.5	8.5
8	1	1.5	8.0	8.0	8.0	16.5	8.0	16.5	16.5	20.0	1.5
8	2	8.0	8.0	8.0	8.0	16.5	16.5	8.0	16.5	8.0	8.0
9	1	3.5	15.5	15.5	9.0	3.5	9.0	15.5	9.0	15.5	15.5
9	2	15.5	3.5	9.0	15.5	9.0	20.0	3.5	3.5	15.5	3.5
10	1	16.0	16.0	19.0	9.5	20.0	16.0	3.0	9.5	9.5	9.5
10	2	9.5	3.0	9.5	3.0	3.0	9.5	9.5	3.0	16.0	16.0
11	1	13.0	13.0	4.0	4.0	13.0	13.0	13.0	19.5	13.0	4.0
11	2	13.0	4.0	13.0	13.0	4.0	19.5	13.0	4.0	4.0	13.0
12	1	9.0	9.0	9.0	2.0	17.5	2.0	9.0	17.5	17.5	9.0
12	2	17.5	9.0	9.0	9.0	17.5	9.0	9.0	9.0	17.5	2 0
13	1	3.0	12.5	3.0	3.0	18.5	12.5	6.5	12.5	18.5	3.0
13	2	3.0	12.5	12.5	20.0	6.5	12.5	12.5	12.5	12.5	12.5

Cont'd......

14	1	9.0	3.0	3.0	9.0	16.0	9.0	9.0	20.0	9.0	3.0
14	2	16.0	16.0	3.0	9.0	9.0	16.0	16.0	16.0	16.0	3.0
15	1	9.5	16.5	16.5	9.5	16.5	2.0	5.0	9.5	16.5	5.0
15	2	9.5	9.5	2.0	9.5	5.0	16.5	2.0	16.5	16.5	16.5
16	1	3.0	3.0	9.0	9.0	9.0	18.0	6.5	18.0	13.0	3.0
16	2	3.0	3.0	18.0	13.0	18.0	13.0	18.0	6.5	13.0	13.0
17	1	15.0	1.5	7.0	15.0	7.0	7.0	7.0	7.0	19.5	7.0
17	2	15.0	15.0	7.0	15.0	15.0	1.5	7.0	15.0	19.5	7.0
18	1	2.5	14.5	14.5	7.0	14.5	7.0	20.0	14.5	14.5	2.5
18	2	14.5	2.5	7.0	7.0	14.5	14.5	7.0	14.5	14.5	2.5
19	1	15.0	15.0	15.0	15.0	15.0	15.0	15.0	5.5	5.5	15.0
19	2	15.0	15.0	15.0	5.5	5.5	1.0	5.5	5.5	5.5	5.5
20	1	16.5	16.5	8.5	16.5	16.5	8.5	2.5	2.5	8.5	16.5
20	2	8.5	8.5	2.5	16.5	16.5	8.5	2.5	16.5	8.5	8.5
21	1	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	6.0	1.0
21	2	6.0	6.0	15.5	6.0	15.5	6.0	6.0	6.0	6.0	6.0
22	1	15.5	15.5	2.0	7.5	15.5	2.0	7.5	15.5	7.5	7.5
22	2	7.5	7.5	7.5	15.5	15.5	20.0	7.5	15.5	15.5	2.0
23	1	1.5	10.0	17.0	10.0	17.0	10.0	1.5	10.0	10.0	10.0
23	2	4.0	17.0	4.0	10.0	17.0	10.0	4.0	20.0	10.0	17.0
24	1	17.0	5.5	17.0	5.5	17.0	12.5	12.5	17.0	5.5	20.0
24	2	5.5	5.5	5.5	17.0	12.5	5.5	5.5	12.5	5.5	5.5
25	1	15.5	15.5	15.5	8.0	3.0	15.5	15.5	3.0	15.5	15.5
25	2	8.0	15.5	3.0	15.5	8.0	8.0	8.0	3.0	15.5	3.0
26	1	20.0	7.5	14.0	7.5	14.0	3.5	14.0	14.0	14.0	3.5
26	2	3.5	3.5	3.5	14.0	14.0	14.0	3.5	14.0	14.0	14.0
27	1	13.5	4.5	13.5	13.5	4.5	13.5	4.5	13.5	4.5	4.5
27	2	13.5	13.5	13.5	4.5	13.5	4.5	19.5	19.5	13.5	4.5
28	1	2.0	2.0	17.5	9.0	9.0	9.0	9.0	17.5	17.5	2.0
28	2	17.5	9.0	17.5	17.5	9.0	9.0	9.0	9.0	9.0	9.0

29	1	5.5	15.5	15.5	5.5	15.5	15.5	15.5	15.5	15.5	5.5
29	2	15.5	5.5	5.5	5.5	5.5	15.5	5.5	5.5	15.5	5.5
30	1	14.0	5.0	1.5	5.0	14.0	14.0	14.0	14.0	1.5	14.0
30	2	14.0	14.0	5.0	5.0	14.0	14.0	5.0	14.0	14.0	14.0
31	1	10.5	10.5	17.0	3.5	10.5	10.5	10.5	20.0	17.0	3.5
31	2	10.5	17.0	3.5	17.0	3.5	17.0	3.5	3.5	10.5	10.5
32	1	11.0	19.0	19.0	11.0	19.0	11.0	11.0	2.5	2.5	11.0
32	2	2.5	11.0	11.0	11.0	11.0	11.0	11.0	2.5	11.0	11.0
33	1	15.0	7.5	2.5	2.5	15.0	7.5	15.0	15.0	7.5	2.5
33	2	15.0	15.0	2.5	7.5	15.0	20.0	7.5	15.0	7.5	15.0
34	1	16.0	6.0	6.0	16.0	16.0	16.0	6.0	16.0	16.0	16.0
34	2	16.0	6.0	16.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
35	1	11.0	11.0	11.0	11.0	11.0	11.0	18.5	18.5	11.0	3.0
35	2	3.0	3.0	3.0	3.0	18.5	18.5	11.0	11.0	11.0	11.0
36	1	16.0	10.5	10.5	4.0	19.5	16.0	4.0	10.5	16.0	4.0
36	2	16.0	4.0	4.0	10.5	16.0	19.5	10.5	10.5	4.0	4.0
37	1	15.0	20.0	15.0	7.5	15.0	7.5	7.5	15.0	15.0	7.5
37	2	15.0	7.5	2.5	2.5	2.5	15.0	7.5	15.0	15.0	2.5
38	1	19.0	6.5	6.5	14.0	19.0	14.0	6.5	19.0	14.0	14.0
38	2	6.5	1.5	6.5	14.0	14.0	6.5	6.5	1.5	14.0	6.5

APPENDICES FOR CHAPTER 6

Observe and draw the specimen provided. دی گئی سلائیڈ کا مشاہدہ کیجئے ۔

Observe the specimen fixed under the microscope. You may use micro-adjustment. Do not move the slide. Draw the specimen at the place provided. Give the name and phylum of the organism.

خوردبین میں لگائی گئی سلائیڈ کا مشاہدہ کیجئے ۔ آپ خوردبین کی Microadjustment استعمال کر سکتے ہیں ۔ مگر سلائیڈ کو اس کی جگہ سے مت ہلائیے ۔ اپنے مشاہدات ذیل میں شکل بنا کر واضح کیجئے ۔ جاندار کا نام اور اس کے فائلم کا نام تحریر کیجئے ۔

Name of Specimen: ____________________

Phylum ____________________

Name: ____________________

Year: ____________________

Roll No: ____________________

Section: ____________________

College: ____________________

عارضی سلائیڈ کا مشاہدہ کیجئے - مشاہدات شکل بنا کر واضح کیجئے -

(a) Observe the temporary slide of the material provided under low and high power of the microscope. Take help to adjust the slide and to focus. Observe and draw the observations below in block (a). Do not remove or move the slide from its place after completing your drawing and show it to the teacher and researcher.

دی گئی سلائیڈ کا مشاہدہ کیجئے - خوردبین کو استعمال کرنے میں مدد حاصل کیجئے - اپنے مشاہدات ذیل میں شکل بنا کر واضح کیجئے - سلائیڈ کو اپنی جگہ سے ہلانے سے پہلے اپنے استاد یا ریسرچر کو اپنے مشاہدات دکھائیے -

(b) Dry the water on the slide by putting corner of tissue paper, on one end of cover slip. Add a drop of solution provided. Observe the slide again and draw the specimen showing your new observations. Without removing the slide from its place show your drawing to your teacher and researcher.

سلائیڈ سے پانی خشک کرنے کے لیے ٹشو پیپر کا کونا کور سلپ کے کنارے پر رکھئے - دوسرے سرے پر دیئے گئے محلول کا ایک قطرہ ڈال دیجئے - سلائیڈ کا دوبارہ مشاہدہ کیجئے اور نئے مشاہدات ذیل میں شکل بنا کر واضح کریں - اور سلائیڈ کو اپنی جگہ سے ہلائے بغیر مشاہدات اپنے استاد کو دکھائیے -

Observation (a)	Observation (b)
Name of Specimen: ______________	

Name: ______________

Roll No: ______________

Year: ______________

Section: ______________

College: ______________

Observe and record your observations on the space provided.

مشاہدہ کیجئے ۔ اور اپنے مشاہدات ذیل میں تحریر کیجئے ۔

You are provided with two types of materials, material A and material B. Test each of these materials one by one with three chemicals; chemical 1, chemical 2, and chemical 3. Observe and record your observations.

آپ کو تین قسم کے مواد فراہم کئے گئے ہیں ، مواد اے اور مواد بی۔ دونوں قسم کے مواد کو باری باری فراہم کردہ تین قسم کے کیمیائی مواد سے جانچئے ۔ اپنے مشاہدات ذیل میں تحریر کریں ۔

1. Take test tube A1. Ask your teacher or the researcher to add chemical 1.

ٹیسٹ ٹیوب اے ایک (A1) لیجئے ۔ اور تحقیق کنندہ یا اپنے ٹیچر سے کہیئے کہ وہ اس میں کیمیکل 1 ڈال دیں ۔

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2. Take test tube A2. Again ask your teacher or the researcher to add chemical 2 in it. Put the tube in boiling water for 7 minutes. Observe and record your observations.

دوسری ٹیسٹ ٹیوب لیجئے یعنی (A2) ۔ اور اپنے ٹیچر یا تحقیق کرنے والے سے اس میں کیمیکل کی مطلوبہ مقدار لیجئے اور ٹیوب کو ابلتے پانی میں 7 منٹ تک رکھ دیجئے ۔ مشاہدات ذیل میں تحریر کیجئے ۔

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3. Take test tube A3. Ask for help to add chemical 3 in it. Observe and record your observations.

تیسری ٹیسٹ ٹیوب (A3) لیجئے اور استاد کی مدد سے اس میں کیمیکل 3 کی مطلوبہ مقدار ڈال کر مشاہدہ کیجئے ۔

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4. Now take test tube B1 with material B in it. Again ask for help to add chemical 1 in it. Observe and record your observations.

اب ٹیسٹ ٹیوب (B1) لیجئے۔ دوبارہ استاد کی مدد سے اس میں کیمیکل ۱ ڈالیے۔ مشاہدات ذیل میں درج کریں۔

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5. Take test tube B2 containing material B. Ask for help to add chemical in it. Put the tube in boiling water for 7 minutes.

ٹیسٹ ٹیوب B2 لیجئے۔ استاد کی مدد سے اس میں کیمیکل 2 ڈالیے۔ اور ابلتے پانی میں 7 منٹ رکھ کر مشاہدہ کیجئے

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____

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6. Take test tube B3. Once again ask your teacher to add chemical 3 in it. Observe the materials. Record your observations.

ٹیسٹ ٹیوب B3 لیجئے۔ دوبارہ استاد کی مدد سے اس میں کیمیکل ۳ ڈالیے۔ مشاہدات ذیل میں درج کریں۔

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Name: ______________________________

Roll No: ______________________________

Year: ______________________________

Section: ______________________________

College: ______________________________

READ THE VOLUME OF WATER

پانی کی مقدار ناپیے ۔

There are three graduated cylinders on the table each with some water in it. Read the volume of water in each cylinder and record it below.

آپ کے سامنے میز پر تین درجہ دار سلنڈر پڑے ہیں ۔ تینوں میں پانی کی کچھ مقدار ہے ۔
آپ نے یہ بتانا ہے کہ ہر ایک سلنڈر میں پانی کی کتنی مقدار ہے ۔ اپنا جواب ذیل میں تحریر کریں ۔

Cylinder A: ________________

Cylinder B: ________________

Cylinder C: ________________

Name: ________________________________

Roll No: ________________________________

Year: ________________________________

Section: ________________________________

College: ________________________________

M1''

6M1

پانی کی مطلوبہ مقدار ناپیے

You are given three graduated cylinders marked as cylinder A, B, and C. Measure the given amount of water in each cylinder.

آپ کو تین درجہ دار سیلنڈر دیئے گئے ہیں۔ ہر ایک سیلنڈر میں ذیل میں دی گئی پانی کی مقدار ڈال دیجئے۔

(a) Measure 57cc of water in cylinder A.

سیلنڈر اے میں 57 سی سی پانی ڈالیے۔

(b) Measure 35cc of water in cylinder B.

سیلنڈر بی میں 35 سی سی پانی ڈالیے۔

(c) Measure 60cc of water in cylinder C.

سیلنڈر سی میں 60 سی سی پانی ڈالیے۔

اپنا نام، رول نمبر، سال اور کالج کا نام لکھنا مت بھولیے۔

Name: ______________________________

Roll No: ___________

Year: ___________

Section: __________

College: ______________________________________

M2

M2

M2

You are given three thermometers, A, B and C. Read and record the temperature on each thermometer and write it below. DO NOT SHAKE THE THERMOMETER. آپ کو تین تھرمامیٹر، اے، بی اور سی دیئے گئے ہیں۔ ہر تھرمامیٹر کا درجہ حرارت پڑھ کر ذیل میں تحریر کر دیجئے۔

Thermometer A: ______________

Thermometer B: ______________

Thermometer C: ______________

Name: ______________________________

Roll No: ______________________________

Year: ______________________________

Section: ______________________________

College: ______________________________

M3

MASS OF THE GIVEN BLOCK OF METAL

دھات کا وزن کیجئے ۔

You are given a metal block. Find out its mass. Record the mass below on the space provided.

فراہم کردہ دھات کا وزن کیجئے اور ذیل میں تحریر کردیں ۔

Name: ____________________

Roll No: ____________________

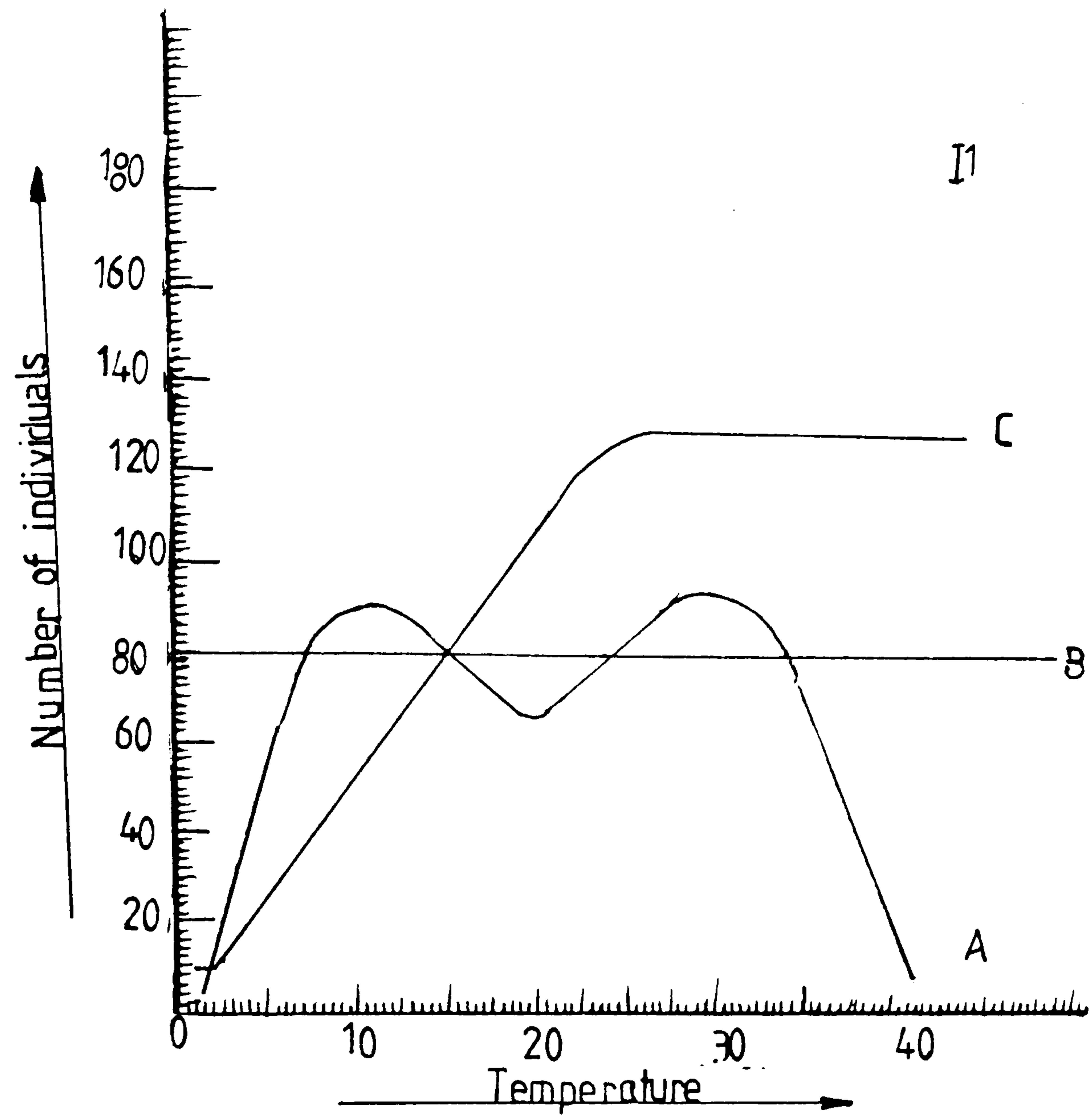
Year: ____________________

Section: ____________________

College: ____________________

6b

6b



The graph drawn above shows the effect of temperature on three animals, animal A, animal B, and animal C. Please read the graph and answer the following questions.

مندرجہ بالا گراف تین جانوروں ، اے، بی اور سی کی آبادی پر درجہ حرارت کے اثرات کی نشاندھی کرتا ھے
گراف کا مطالعہ کیجئے اور مندرجہ ذیل اور اگلے صفحوں پر پوچھے گئے سوالات کے جواب تحریر کیجئے -

1. Which of the three populations is Most badly effected by temperature?

کس جانور کی آبادی پر درجہ حرارت کا سب سے برا اثر پڑا -

A ☐ B ☐ C ☐ None ☐

2. Which of the three populations is least effected by temperature?

کس جانور کی آبادی پر درجہ حرارت کا سب سے کم اثر پڑا -

A ☐ B ☐ C ☐ None ☐

3. What is the effect of temperature on the population of animal C from $0^\circ C$ to $40^\circ C$? زیرو سے ۴۰ ڈگری کے درمیان جانور سی کی آبادی پر کس طرح کے اثرات مرتب ہوئے

4. At which temperature are the number of amoeba in population A, B and C the same? کس درجہ حرارت پر جانور اے بی اور سی کی آبادی میں نفوس کی تعداد برابر تھی ۔

5. At what temperature would you see maximum number of individuals in the population of animal A?
کس درجہ حرارت پر جانور اے کی آبادی میں نفوس کی تعداد انتہائی تھی ۔

6. What was the approximate number of individuals in the population of animal C at $20^\circ C$?
۲۰ ڈگری سی پر جانور سی کی آبادی کتنی تھی ۔

7. At 10° C what was the population of animal A?
۱۵ ڈگری سی پر جانور اے کی آبادی کتنی تھی ۔

8. Between which temperatures did the population of animal A increase most rapidly?

کن دو درجہ حرارت کے درمیان جانور اے کی آبادی میں انتہائی تیز رفتاری سے اضافہ ہوا ۔

9. Which one of the three populations has a fairly large population at 0 C?

تینوں جانوروں میں سے کس جانور کی آبادی صفر ڈگری درجہ حرارت پر بھی کافی زیادہ تھی ۔

نام، رول نمبر، سال اور کالج کا نام تحریر کرنا مت بھولیے ۔

Name: ________________

Roll No: ________________

Year: ________________

Section: ________________

College: ________________

CRITERIA FOR THE TASK ON INTERPRETING AND READING GRAPH I1

(1) Animal A

(2) Animal B

(3) At first the population increased than became constant

(4) At 15° C

(5) At 30° C

(6) 108 ± 2

(7) 90

(8) 2° to 7°C

(9) Animal B

TOTAL POSSIBLE SCORE = 9

SCORE REQUIRED FOR COMPETENCY = 5

گراف کا مطالعہ کیجئے ۔

INTERPRET AND READ THE GRAPH

A researcher studied the changes in the population of amoeba kept under three different temperatures, 10 C, 26 C, and 37 C.

ایک ریسرچر نے امیبا کی تعداد پر درجۂ حرارت کے اثرات کا مطالعہ کرنے کے لیے امیبا کو تین درجۂ حرارت پر رکھا۔ 10، 26 اور 37 درجہ سی۔ اور کچھ گھنٹوں تک ان کا مشاہدہ کیا ۔

He plotted a graph of data obtained. The graph is given on page 2. Read the graph and answer the questions given below and on the following pages.

مشاہدات سے حاصل شدہ نتائج اس نے ایک گراف کی شکل میں پیش کیے۔ یہ گراف اگلے صفحہ پر دیا ہوا ہے آپ نے گراف کا مطالعہ کرنا ہے اور ذیل میں پوچھے گئے سوالات کا جواب دینا ہے ۔

---

1. After two hours of observation what was the population of amoeba kept at 26°C? Write your answer below.
   دو گھنٹے کے مشاہدات کے بعد 26 ڈگری سی پر رکھے گئے امیبا کی آبادی کتنی تھی ۔

   ____

2. After how long were there 100 individuals in the population of amoeba kept at 37°C?
   کتنے گھنٹوں یا منٹوں کے بعد 37 ڈگری سی پر رکھے گئے امیبا کی آبادی میں 100 امیبا تھے ۔

   ____

3. After 60 minutes how long did it take to amoeba kept at 26 C to double its population.
   60 منٹ کے بعد 26 درجہ سی پر رکھے ہوئے امیبا کو اپنی تعداد دگنی کرنے میں کتنا وقت لگا ۔

   ____

4. At what temperature do you think the population of amoeba increased at a slow and steady rate?
   کس درجہ حرارت پر امیبا کی تعداد میں سست مگر یکساں شرح سے اضافہ ہوا ۔

   ____

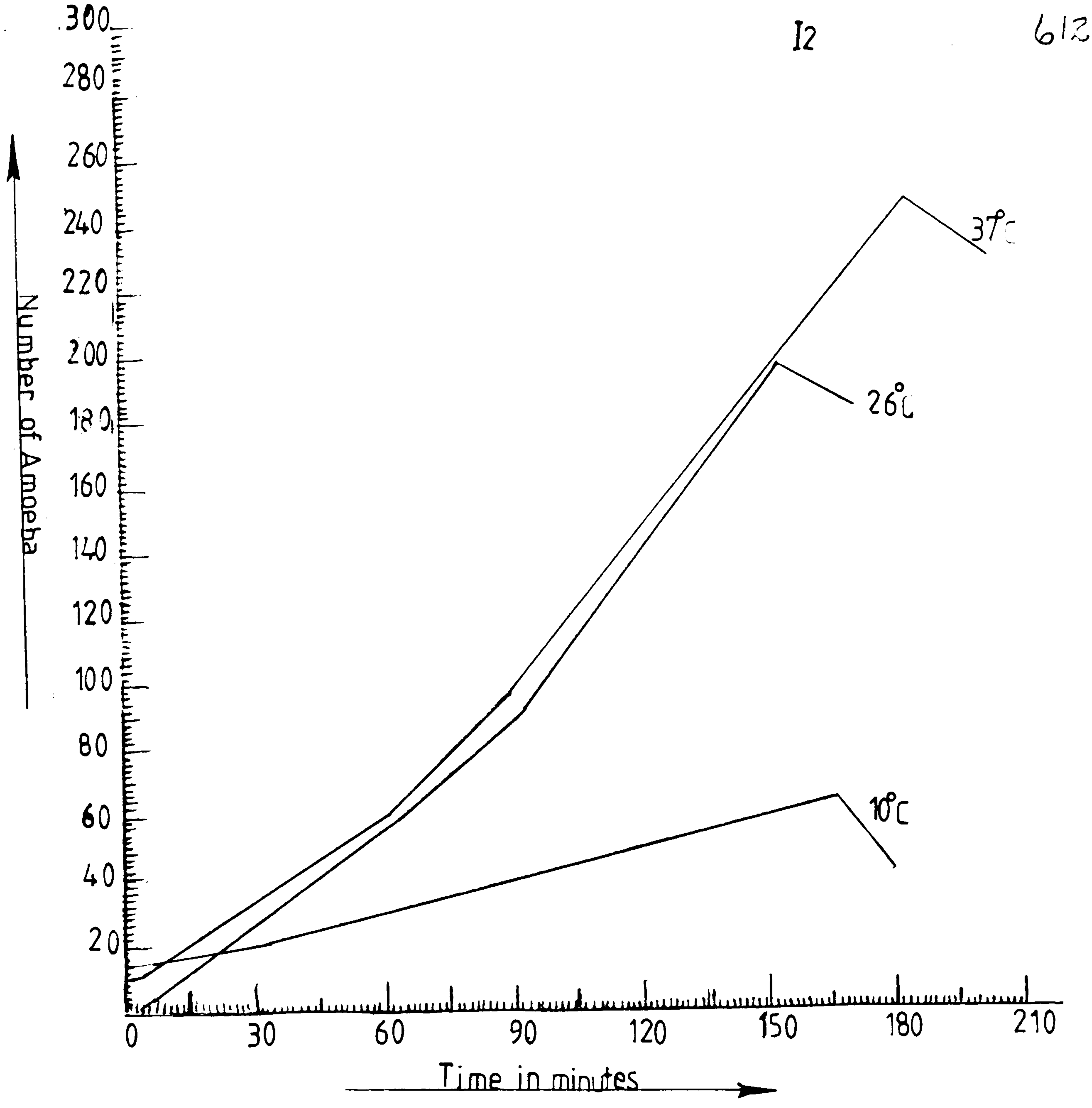
5. During the first 60 minutes of observation, which one of the three populations of amoeba increased most rapidly?
   مشاہدات کے ابتدائی 60 منٹ کے دوران کس امیبا کی تعداد میں تیز رفتاری سے اضافہ ہوا ۔

   ____

6. After three hours of observation what was the population of amoeba kept at 37°C.
   مشاہدات کے تین گھنٹوں کے بعد 37 درجہ سی پر رکھے ہوئے امیبا کی تعداد کتنی تھی ۔

   ____

CONT'D ...


I2
612
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
Number of Amoeba
37°C
26°C
10°C
0
30
60
90
120
150
180
210
Time in minutes

7. After one and a half hours what was the difference between the population of amoeba kept at 37° C and 26° C?

ڈیڑھ گھنٹے کے مشاہدات کے بعد 26 اور 37 ڈگری سی پر رکھے ہوئے امیبا کی تعداد میں کتنا فرق تھا ۔

____

8. When there were 120 amoeba in the population of amoeba kept at 37° C what was the number of amoeba in the population of amoeba kept at 26° C?

جب 37 درجہ سی پر رکھے ہوئے امیبا کی تعداد 120 تھی اس وقت 26 درجہ سی رکھے ہوئے امیبا کی تعداد کتنی تھی ۔

____

9. From the information given in the graph, which one of the three populations of amoeba reached its maximum size first?

گراف میں دی گئی معلومات کی بنیاد پر یہ بتایئے کہ تینوں میں سے کس امیبا کی تعداد اپنی انتہا کو سب سے پہلے پہنچی

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Name: ____________________

Roll No: ____________________

Year: ____________________

Section: ____________________

College: ____________________

CRITERIA FOR THE TASK ON INTERPRETING AND READING GRAPH I2

(1) 152 ± 2

(2) 90 ± 2

(3) 42 ± 2

(4) 10° C

(5) 26° C

(6) 256 ± 2

(7) 10 ± 2

(8) 108 ± 2

(9) 26° C

TOTAL POSSIBLE SCORE = 9

SCORE REQUIRED FOR COMPETENCY = 5

Draw a graph from the data provided. دیئے گئے اعداد و شمار سے گراف بنایئے۔

In an experiment an apparatus was set up to measure the amount of Carbon Dioxide produced during the process of fermentation. The amount of Carbon Dioxide produced was measured after short intervals of time.

ایک تجربہ میں Fermentation کے دوران بننے والی کاربن ڈائی آکسائیڈ کی مقدار ناپنے کے لیے ایک آلہ مرتب کیا گیا۔ اور تھوڑے تھوڑے وقفوں کے بعد نکلنے والی کاربن ڈائی آکسائیڈ کی مقدار ناپی گئی۔

The data gathered in this experiment is given in the Table A.

Your task is to convert this Table into a graph. Graph paper is provided. Please write your name, roll number and year on the graph paper.

تجربہ سے حاصل شدہ اعداد و شمار ذیل میں درج ہیں۔ ان اعداد و شمار کو گراف کی شکل میں پیش کریں۔
گراف کاغذ فراہم کیے گئے ہیں۔ ان پر اپنا نام، رول نمبر، اور سال و کلاس کا نام لکھنا مت بھولیے۔

Time In Minutes	Amount of CO_2 Produced (ml)
5	3
10	10
15	13
20	15
25	17
30	18
35	20
40	21
50	23
55	25
60	27
65	28
75	30
85	33
105	38

6P

P:- PREDICT THE RESULT OF EXPERIMENTS. پیشن گوئی کیجئے

1. We take two leaves from a plant: Leaves are approximately of same size. Now we hang these leaves on a coke straw, and we balanced the straw and leave it for a while. What will happen to the straw after

ہم دو پتے تقریباً ایک ہی جسامت کے اور ایک ہی پودے سے لے کر ان کو کوک پینے کی نلی کے سروں سے لٹکا دیتے ہیں۔ اور لعاب کی مدد سے نلکی کو ہموار کر دیتے ہیں۔ نلکی اب متوازن ہے۔ کچھ دیر کے بعد آپ کی رائے میں نلکی کی کیا حالت ہوگی۔

some time, will it;

Remain balanced	☐	یہ متوازن ہی رہے گی۔
Its red end will move down	☐	اس کا سرخ سرا جھک جائے گا۔
Its red end will move up	☐	اس کا سرخ سرا اوپر اٹھ جائے گا۔

Tick the prediction you think is right.

جو جواب بھی آپ کی رائے میں درست ہے اس پر درست کا نشان لگا دیجئے۔

2. You have seen the results of first experiment. Now we take two new leaves again from same plant and of same size. This time we coat a thin layer of vaseline on the lower surface of one leaf, and hang it on the red end of our straw. We take the other leaf and hang it on the other side of the straw. This leaf has no vaseline on it. We balance the straw. Now after some time what will

آپ نے پہلے تجربے کے نتائج کا مشاہدہ کیا۔ اب ہم دو نئے پتے تقریباً ایک ہی جسامت کے لے کر ایک کی نچلی سطح پر ویسلین کی باریک سی تہ جما دیتے ہیں۔ اس پتے کو ہم نلکی کے سرخ سرے سے لٹکا دیتے ہیں۔ دوسرا پتہ لے کر اسے نلکی کے سادہ سرے سے لٹکا دیتے ہیں۔ یہ پتہ سادہ ہے۔ دوبارہ نلکی کو متوازن کر دیتے ہیں۔ اب کچھ دیر کے بعد نلکی کی کیا حالت ہوگی۔

be the position of straw, will it;

Remain balanced	☐	یہ متوازن ہی رہے گی۔
Its red end will move down	☐	اس کا سرخ سرا جھک جائے گا۔
Its red end will move up	☐	اس کا سرخ سرا اوپر اٹھ جائیگا۔

Tick the prediction you think is right.

جو جواب بھی آپ کی رائے میں درست ہے اس پر درست کا نشان لگا دیں۔

3. You have seen the results of first and second experiments; Let us do another experiment. We take two new leaves from the same plant and of same size. This time we coat the upper surface of one leaf and hang it on red end of our straw. We hang the plain leaf on the other side of the straw and balance the straw. Now what it your prediction about the position of straw, will it;

آپ نے پہلے اور دوسرے تجربہ کے نتائج دیکھے۔ آیئے ایک اور تجربہ کرتے ہیں۔ ہم دو نئے پتے لے کر ایک کی اوپر کی سطح پر ویسلین لگا دیتے ہیں۔ اور اسے نلکی کے سرخ سرے پر لٹکا دیتے ہیں۔ دوسرے پتے کو نلکی کے سادہ سرے سے لٹکا دیتے ہیں۔ اب آپ کی پیش گوئی کیا ہے۔

Remain balanced	☐	یہ متوازن ہی رہے گی۔
The red end will move down	☐	اس کا سرخ سرا جھک جائیگا۔
The red end will move up	☐	اس کا سرخ سرا اوپر ہو جائے گا۔

Tick the prediction you think is correct.

جو جواب بھی آپ کی رائے میں درست ہے۔ اس پر درست کا نشان لگا دیں۔

4. Now let us try another experiment.

This time let us take another two leaves from the same plant. Again the leaves are of approximately the same size. Now we coat the upper surface of one leaf and hang it on red end of our straw. Then we coat upper and lower surface of the other leaf and hang it on the plain end of our straw. We balance the straw. Now what it your prediction, will it;

آیئے ایک اور تجربہ آزماتے ہیں۔ اس مرتبہ دو نئے پتے ایک ہی پودے سے لیتے ہیں۔ دوبارہ یہ پتے تقریباً ایک ہی جسامت کے لے کر ایک کی اوپر کی سطح پر ویسلین لگا دیتے ہیں۔ اور اسے نلکی کے سرخ سرے سے لٹکا دیتے ہیں۔ دوسرے پتے کی اوپر کی اور نیچے کی سطح پر ویسلین لگا دیتے ہیں۔ اور اسے نلکی کے سادہ سرے سے لٹکا دیتے ہیں۔ اور نلکی کو متوازن کر دیتے ہیں۔ اب آپ کی کیا پیش گوئی ہے۔

Remain balanced	☐	یہ متوازن ہی رہے گی۔
Its red end will move down	☐	اس کا سرخ سرا جھک جائے گا۔
Its red end will move up	☐	اس کا سرخ سرا اوپر ہو جائے گا۔

Tick the prediction you think is correct.

5. Let us try another experiment. This time we take two new leaves, again from the same plant and of same size. We coat the upper surface of both leaves with vaseline and hang them on our straw. We balance the straw

آئیے ایک اور تجربہ کرتے ہیں۔ اس مرتبہ دو تازہ پتے لے کر دونوں پتوں کی اوپری سطح پر ویسلین
لگا دیتے ہیں۔ اور ان کو تنکی کے دونوں طرف لٹکا دیتے ہیں۔ اور تنکی کو متوازن
کر دیتے ہیں۔

and leave it for a while. Now what is your prediction about the position of straw, will it;

Remain balanced	☐	یہ متوازن ہی رہے گی۔
Its red end will move down	☐	اس کا سرخ سرا جھک جائے گا۔
Its red end will move up	☐	اس کا سرخ سرا اوپر اٹھ جائے گا۔

Tick the prediction you think is correct.

---

6. One last experiment! Again we take two new leaves. We coat upper and lower end of one leaf and hang it on red end of straw. We coat the upper surface of other leaf and hang it on plain end of straw. Balance the straw and leave it for a while. Now what is your prediction,

ایک آخری تجربہ کرتے ہیں۔ دوبارہ دو نئے پتے لے کر ایک کی اوپری اور نچلی دونوں سطح پر
ویسلین لگا دیتے ہیں۔ دوسرے پتے کی صرف اوپری سطح پر ویسلین لگاتے ہیں۔ اور اسے اپنی
تنکی کے سادہ سرے پر لٹکا دیتے ہیں۔ جس پتے کے دونوں جانب ویسلین لگا کر اسے سرخ
سرے پر لٹکا دیتے ہیں۔ اور تنکی کو متوازن کر دیتے ہیں۔ اب آپ کی پیشن گوئی
کیا ہے۔

will it;

Remain balanced	☐	یہ متوازن ہی رہے گی۔
Its red end will move down	☐	اس کا سرخ سرا جھک جائے گا۔
Its red end will move up	☐	اس کا سرخ سرا اٹھ جائے گا۔

Tick the prediction you think is correct.

Name: ____________________

Roll No: ____________________

Year: ____________________

Section: ____________________

College: ____________________

CRITERIA FOR THE TASK ON MAKING PREDICTIONS P

(1) Remain balanced

(2) Red end will move down

(3) Remain balanced

(4) Red end will go up

(5) Remain balanced

(6) Red end will move down

TOTAL POSSIBLE SCORE = 6

SCORE REQUIRED FOR COMPETENCY = 4

APPENDIX 6A

Results of performance of Students from EPB User Degree Colleges for Boys in each skill

Key: X = No reached level of competency. V = Reached level of competency

College Code.	Students	O	M	G	I	P	Total No. of Skills Attained.
AL	1	x	x	v	v	v	3
	2	x	v	v	v	x	3
	3	x	x	v	v	v	3
	4	v	x	v	v	v	4
	5	x	x	v	x	x	1
	6	x	x	v	v	x	2
BD	7	v	v	x	v	v	4
	8	v	v	v	v	v	5
	9	v	v	v	v	v	5
	10	x	v	v	x	x	2
	11	v	v	x	x	v	3
	12	v	v	x	x	x	2
DG	13	x	v	v	x	x	2
	14	x	v	x	x	x	1
	15	x	v	x	x	x	1
	16	x	v	v	v	x	3
SCC	17	v	v	x	x	v	3
	18	x	v	x	x	x	1
	19	x	v	x	x	x	1
	20	x	v	v	v	x	3
	21	x	v	x	x	x	1
SRA	22	x	v	x	x	x	1
	23	x	x	x	x	x	0
	24	x	x	x	x	x	0
	25	x	x	x	x	v	1
	26	x	x	x	x	v	1
	27	x	x	x	x	v	1
No. of Students attaining competency in each skill		07	17	12	10	11	

APPENDIX 6B

Results of performance of Students from BSCS Colleges for Boys and Girls

Key: X = Not reached level of competency; V = Reached level of competency

	College Code	Students	O	M	G	I	P	Total No. of Skills Attained
Male Degree Colleges	F.C.	1	x	v	v	v	v	4
		2	x	v	v	v	x	3
		3	x	v	v	v	v	4
		4	v	v	x	v	v	4
		5	v	v	x	v	v	4
	G.C.	6	v	v	v	v	x	4
		7	v	v	v	v	v	5
		8	v	v	v	x	v	4
		9	v	v	v	v	v	5
		10	v	v	v	v	v	5
		11	v	v	x	v	v	4
Female Degree Colleges	R.C.	12	v	v	x	v	v	4
		13	x	v	x	v	v	3
		14	v	v	x	v	v	4
		15	v	v	x	v	v	4
	G.M.	16	v	v	x	v	v	3
		17	x	v	x	x	x	1
		18	x	v	x	x	x	1
		19	x	v	x	x	x	1
		20	x	v	x	x	x	1
		21	v	x	x	v	x	2
No. of Students attaining competency in each skill			13	20	08	16	13	

APPENDIX 6C

TABLE 6: Results of performance of Students from EPB User Degree Colleges for Girls in each of the five skills included in CSA

Key: X = Not reached level of compentency; V = Reached level of compentency

College Code	Students	Skills O	M	G	I	P	Total No. of Skills Attained by each Student
Aa	1	v	v	x	x	x	2
	2	x	x	v	x	v	2
	3	v	v	x	x	v	3
	4	v	x	x	x	x	1
	5	v	v	v	x	x	3
Gg	6	x	x	x	v	x	1
	7	v	v	v	v	v	5
	8	v	v	x	x	x	2
	9	v	v	x	v	x	3
	10	v	v	v	v	x	4
	11	x	x	v	x	x	1
Jm	12	v	x	x	v	v	3
	13	x	x	x	v	x	1
	14	v	x	v	v	x	3
	15	v	x	v	v	v	4
	16	v	x	x	x	x	1
	17	x	x	v	x	v	2
Ed	18	x	x	x	x	v	1
	19	v	v	v	x	x	3
	20	x	x	x	x	x	0
	21	v	v	v	x	x	3
	22	x	v	x	x	x	1
Va	23	x	x	x	x	v	1
	24	x	x	x	x	x	0
	25	x	x	v	x	x	1
	26	x	x	v	x	v	2
	27	x	x	v	x	x	1
	28	x	x	x	x	v	1
No. of Students Attaining Compentency in each skill		14	10	13	08	10	

APPENDIX 6D

Number of skills in which each Student from EPB User Intermediate Colleges attained the level of Competency

College Code	Students	Skills O	M	G	I	P	Total No. of Skills in which each Student is Competent.
JM	1	v	v	x	v	v	4
	2	x	x	x	x	v	1
	3	v	v	x	x	v	3
	4	v	v	x	x	v	3
	5	x	x	v	x	v	2
Mt	6	x	x	x	x	v	1
	7	x	x	x	x	x	0
	8	x	x	v	x	x	1
	9	x	x	x	x	x	0
Sr	10	x	v	x	x	x	1
	11	v	v	x	v	v	4
	12	x	v	x	x	v	2
	13	x	v	x	v	x	2
Gk	14	x	x	x	x	v	1
	15	x	x	x	x	x	0
	16	v	x	x	x	v	2
	17	x	x	x	x	v	1
	18	v	v	x	x	x	2
KB	19	v	v	x	x	x	2
	20	v	x	x	x	x	1
	21	x	v	x	x	x	1
	22	x	v	x	x	x	1
	23	x	x	x	x	x	0
	24	x	v	x	x	x	1
Mn	25	v	v	v	v	x	4
	26	v	v	x	v	x	3
	27	v	v	x	v	x	3
	28	v	v	x	x	x	2
	29	v	v	x	x	v	3
	30	v	v	v	v	x	4
No. of Students Attaining Competency in each skill		14	18	4	7	12	

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