

Evaluation in science and technology education

Overview

4.1

Evaluation is an integral part of the teaching-learning processes. Through systematic evaluation procedures science and technology teacher educators can measure the progress of pre-service and in-service teacher trainees in attaining the objectives of teaching programmes. Evaluation also enables teacher educators to measure the effectiveness of their own teaching strategies and methods. Similarly, teachers trainees need to develop skills and competence in evaluation techniques which they can then apply in their own teaching in schools. Evaluation results can also play a part in an accountability system for ensuring that institutions, teacher educators and teachers deliver good quality science and technology education.

It is important that the objectives of a lesson or course should be clear, so that science and technology teacher educators can select appropriate learning experiences, teaching methods and information-gathering techniques in order to achieve the objectives.

Objectives

4.2

This monograph aims at helping science and technology teacher educators to:

- acquire the necessary knowledge and skills to evaluate teacher trainees;
- acquire the skills of evaluating their own teaching;
- become aware of the problems associated with evaluation;
- become aware of the need for and methods of record keeping;
- develop the necessary understanding and skills of evaluation amongst teacher trainees.

4.3 The purpose of evaluation

Evaluation is carried out for the following purposes:

- to measure progress;
- for accreditation and certification;
- to determine whether objectives of a teaching programme have been achieved;
- to rank learners;
- to identify gaps in the knowledge and skills of learners;
- to provide information on progress to parents, teachers, teacher educators and decision makers;
- to improve the teaching-learning process.

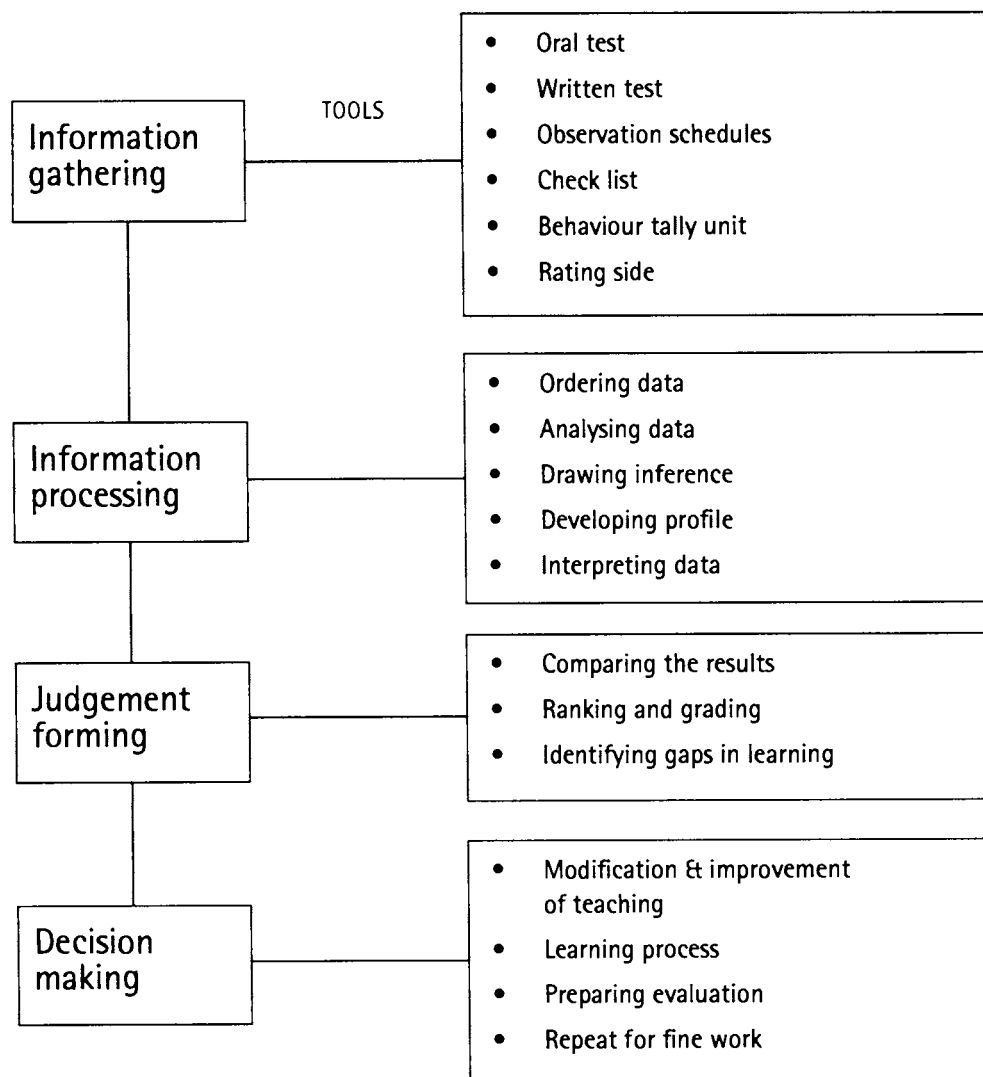
The teacher educator should emphasise to the teacher trainees that the purpose of evaluation is not only to let the learner and parents know about the progress of the learner, it is also of vital importance to teachers because it informs them about the success of their own teaching. Information from evaluation can be used by teachers to plan and improve their lessons. This should be demonstrated by the teacher educator.

4.4 Types of evaluation

Evaluation is a process of information gathering, information processing, judgement forming and decision making.

Evaluation may be carried out to collect a variety of information about teacher trainees, such as academic performance, performance in the classroom, ability to handle classroom material, presentation and communication skills and ability to plan and execute practical work. Similarly, teacher educators may evaluate trainees with regard to their knowledge and skills in planning and administering evaluation in schools.

The purpose of evaluation and the use of information collected determine the nature of evaluation. If the information is used to diagnose the cause of a particular problem faced by a teacher trainee, the evaluation is called diagnostic. If information gathered is used to monitor teachers' progress during pre-service or in-service programmes and to take corrective measures whenever required, evaluation is called formative. This type of evaluation is carried out periodically and is therefore also called continuous evaluation. Evaluation which is carried out at the end of a course or session is called summative evaluation. The scheme of evaluation should be both continuous and comprehensive. A procedure of evaluation which adequately measures both cognitive and non-cognitive learning outcomes is commonly known as comprehensive evaluation. The scheme of evaluation which takes care of both the aspects – continuity and comprehensiveness of evaluation, is called continuous and comprehensive evaluation.



Formative evaluation

4.4.1

Formative evaluation is carried out to provide the teacher, as well as the learner, with feedback that can be used in taking corrective measures at different stages in the teaching-learning process. Objectives of formative evaluation are:

- to determine the progress being made by the learners and the difficulties they may be experiencing;
- to guide the learning process;
- to decide which learners need further help and the nature of activities and strategies that might help them;
- to pace the learning process and make the learner more alert to his or her performance.

Formative evaluation is conducted mainly to improve learning. This does not mean that tests used for formative evaluation cannot be graded. However, the grading is

done to find strengths and weaknesses in the teaching-learning process. Formative evaluation, therefore, provides both teachers and learners with feedback on the achievement of the objectives. Teacher educators should model how this can be done in their own teaching.

4.4.2 Continuous and comprehensive evaluation

Evaluation forms an integral part of teaching-learning process. continuous evaluation of learner's achievement is carried out periodically during the teaching-learning process to judge if the competency has been mastered by the learner. Evaluation is commonly done only in the cognitive areas of learning such as knowledge and understanding and some basic skills. Evaluation of non-cognitive areas of learning such as values, interests, attitudes, habits, etc. is hardly attempted. Effective evaluation procedures need to be employed so as to measure both cognitive and non-cognitive learning outcomes. Emphasis should not be on measurement of learner's learning alone but for improvement of their achievement on a regular basis. If some 'slow' learners not ready to develop or learn competency completely, their weaknesses need to be diagnosed and the hard spots of learning identified and followed by appropriate remedial programme. Evaluation therefore should be continuous and comprehensive for evaluating learners' achievement in both cognitive and non-cognitive areas on a regular basis for their scholastic and non-scholastic growth, by the teacher through periodical tests by employing variety of tools, techniques and regular feed back. The final grade a learner receives in a course or session is not based on a single final annual examination, but takes into account the results of the evaluation through the session.

Characteristics of continuous and comprehensive evaluation

The continuous and comprehensive evaluation need to be:

- **Continuous:** The word continuous refers to regularity in testing. The development of learner is a continuous process, we need to know at every stage the degree of development so as to initiate appropriate remedial or enrichment measures as and when needed. This can be ensured only when assessment is carried out on continuous basis through periodical tests by the teacher.
- **Comprehensive:** Through education we want all round development of learner which includes development of both cognitive and non-cognitive abilities. The development of cognitive and non-cognitive abilities can be ensured only when we go in for comprehensive evaluation taking into cognisance of each and every specific objective pertaining to both the domains. Besides, comprehensive evaluation is an integral part of system of education, interlinked with educational objectives and teaching process. This holistic evaluation provides valuable information on the teacher trainee's performance.
- **Systematic:** All measurements at different time interval have to be planned systematically.
- **Guidance-oriented:** Test result should be used for improvement of learning process. The emphasis should be more on improvement rather grading the achievement.

Evaluation is oriented towards providing guidance in that the information obtained is used to guide the teacher trainee's future professional development.

- **Flexible:** The teacher educator should be able to adapt his evaluation programme in accordance with his/her own teaching schedule and needs of his/her class along with other factors.
- **Economical:** Evaluation should be carried out in such a way that it is economical in terms of time, effort and money.
- **Diagnostic:** The deficiencies identified in learning should provide basis for remedial measures.
- **Co-operative:** There should be involvement of teachers, learners, parents, peers, observers and even community members to make it more objective, reliable and valid.
- **Functionality:** Evaluation should not be too technical and cumbersome. It should be based on possible available resources and inputs.
- **Gender sensitive:** In framing questions attention should be taken to ensure that there is no gender bias of any kind.

It is important that teacher educators demonstrate these characteristics of continuous and comprehensive evaluation in the evaluation of the teacher trainees and then enable the teacher trainees to use the strategies with their learners during teaching practice. This will help the teacher trainees to develop appropriate skills.

Problems associated with continuous and comprehensive evaluation

Teacher educators should be aware of the problems outlined below, discuss them with teacher trainees, offer suggestions and allay fears.

- **Workload of the teacher:** There can be no denying that continuous and comprehensive evaluation makes demands on the teacher. Whether this work is above and beyond that which the teacher can reasonably be expected to undertake as part of teaching depends on particular situations. As was stressed above, evaluation and feedback are essential in teaching. Where continuous and comprehensive evaluation is used to provide feedback, it is reasonable to expect teachers to integrate this into their normal workload.

The problem with continuous and comprehensive evaluation arises, however, when the learning outcomes need to be recorded for use by other teachers and outside agencies. This usually has to be done in a standard format that involves the teachers in additional record keeping work and carrying out evaluations at stipulated periods for record keeping rather than at times most appropriate to the teaching situation.

- **Teacher learner relationship:** Some teachers are concerned that formally evaluating learners will interfere with teacher learner relationships and with the role of the teacher in providing feedback and counselling. The perception is that learners will be afraid to give ideas and opinions because they may be penalised during evaluation.

Teacher educators must realise that evaluation and feedback are one and the same and that evaluation, of any form, needs to be an integral part of teaching. When learners understand this and are able to establish and accept the need for evaluation and feedback, the teacher learner relationship can be enhanced. It appears that the fear of teacher trainees is associated with an inability to link evaluation with teaching.

4.4.3 Summative evaluation

Evaluation which is carried out at the end of a course with the sole purpose of grading, promotion or selection is termed summative evaluation. Results of summative evaluation are also used for accountability purposes of individual teacher educators or teachers or of their institutions. Summative evaluation also informs policy makers about the standards of education and the efficacy of the curriculum.

Summative evaluation is normally carried out using paper and pencil tests and/or practical tests administered towards the end of a term or academic year. Such tests may be conducted by the institution itself or by an external examining agency.

In some countries, teacher trainees' success or failure at the end of a teacher education programme is mainly determined by an external examination body. It has been advocated that teacher educators should have some input in determining the final grades of their teacher trainees.

For a valid evaluation of the teacher trainee, the results of continuous and comprehensive evaluation should be used to supplement summative evaluation.

4.5 Tools and techniques for Evaluation

The objectives of science and technology education about which information will have to be collected are in the areas of :

- knowledge and understanding of science facts, principles, methods and materials;
- process skills such as observing, classifying, communicating, inferring, hypothesising, experimenting, designing and problem solving;
- attitudes, interests, curiosity, critical thinking, perseverance and openness.

A variety of techniques can be employed to collect information about learners' progress. Some of the important techniques are given below:

- written tests;
- practical tasks carried out by individuals or groups;
- questionnaires;
- scheduled interviews;
- rating scales;

- check lists;
- observation during normal activities;
- written records of work produced including drawings;
- listening to oral explanations.

Evaluation through observation during normal activities

4.5.1

Observation (as a technique to collect information) provide qualitative information about the objectives being evaluated. Through observation skills, attitudes and acquisition of concepts can be evaluated over an extended period of time. Since the learners are being evaluated through observation of their normal activities, they are not under stress; also, there is no loss of teaching-learning time. All the learners need not be evaluated at the same time through one activity. To aid observation, actual classroom activities could be video-recorded. These recordings could also be used by teacher trainees to develop and practise observation skills.

Observation is a very powerful information-gathering technique since it can be used to collect information about a wide range of behaviours spread over several objectives. However, the teacher educators and the teacher trainees need to recognise that observation goes beyond simply looking at what learners are doing. For the technique to be used successfully, the activities to be observed and the particular stages within them, must be clearly identified. The emphasis is not on observing whether or not the learner is doing the right things but on what the learner can or cannot do.

In addition, criteria have to be established, against which observations can be measured and recorded. The criteria are generally derived from the learning objectives and the stage of development of the teacher trainee. This aids proper interpretation of the observations and in establishing the learners' progress, information which is very useful for the teacher educators and teacher trainees in planning future activities for the learners.

One disadvantage of collecting evaluation information through observation is the element of subjectivity. The observer has to be skilled in the technique. An unskilled observer may miss certain important factors that should be noted.

Using written tests for gathering information

4.5.2

Written tests may contain a variety of questions such as:

- Objective type questions (multiple choice, fill in the blank, True/False and matching)
- Very short answer
- Short answer
- Essay type

Written tests are used mainly for collecting information about learners cognitive abilities and some drawing skills. They cannot be used for testing a wide range of psychomotor skills. They can, however, be used for both formative and summative evaluation. Most written tests include essay-type and multiple-choice questions, and some characteristics of these are listed below. The language used should be simple, precise with no ambiguity.

Essay-type questions

These questions require more extended written answers and the ability to integrate and express ideas involving:

- description, explanation and prediction of processes and structures;
- description of instruments, apparatus, etc.;
- factual knowledge;
- interpretation of experimental numerical data;
- discussion of results of experiments and solutions of problems.

Advantages

- They reduce guesswork in answers.
- They reduce the possibility of cheating.
- They provide freedom of response.

Disadvantages

- In marking essay type questions, the teacher tends to carry impressions from one paper to another.
- Essay type questions cannot be used effectively with learners with low levels of language development.

Evaluation through essay type questions at primary school level should be limited to short paragraphs only.

Multiple-choice type questions

Multiple-choice questions can be useful in covering a range of curricular objectives. A multiple-choice question usually consists of a question or statement, called the 'stem', followed by four or five choices of answers or 'options'. The stem may also be a partial statement that is completed by one of the choices. Only one of the options is the correct answer to the question or ending to the statement. The other options are called 'distracters'.

Other forms of multiple-choice questions include:

- **True/false questions:** These are not particularly useful since there is a 50% chance of guessing the right answer.

- **Fill-in-the-blank questions:** Here possible responses may or may not be supplied to the learner. If responses are provided the learner selects the most appropriate response. To reduce the chances of guessing, more than two response should be provided.
- **Matching questions:** These are presented in the form of two lists of statements. For each statement in one list there is one correct statement in the other list and the learners have to match them. The primary cognitive skill tested by matching exercises is 'recall'.

Teacher education programmes should include practice in the construction and review of different types of questions and written tests. The review should include analysis of each item of the test.

Using oral test

4.5.3

Formal examination at least in the first two classes of the primary stage may be avoided and 'oral mechanism' of evaluation for these two classes can be devised so that the learners gain competencies of the basic skills which are expected to be mastered in these classes.

Exemplars of oral mechanism

Oral questioning has all along been a part of the classroom activity. At this stage the teacher can use the following mechanism.

- Quiz contest
- Single question put to individuals in a group while lesson is being taught.

The following aspects in language used for science and technology education could be tested through oral mechanism.

- 1 To speak with correct articulation and intonation.
- 2 To speak grammatically correct language
- 3 Vocabulary and its usage
- 4 Delivery (communication skills)

Also, a quiz competition can be organised.

The techniques for oral examination are:

- (i) reading aloud picture story card;
- (ii) prepared questions;
- (iii) conversation on prepared topics;
- (iv) general conversation;
- (v) questions on pictures and role playing, etc.

4.5.4 Other tools and techniques

In order to keep a record of learners qualitative account of behaviour teacher educator can resort to a variety of tools such as checklists, behaviour tally charts and rating scales.

Some examples of these tools are given below:

Rating scale

Instructional focus: Enquiry of the quality and process of work

- 1 Relevance of action to word:
 - (a) Seldom
 - (b) Sometimes
 - (c) Most of the time
- 2 Shows keen interest:
 - (a) Seldom
 - (b) Sometimes
 - (c) Most of the time
- 3 Clarity in pronunciation
 - (a) Seldom
 - (b) Sometimes
 - (c) Most of the time

Name of pupil _____

Observer _____

Activity _____

S. No	Criteria	Rating		
		A	B	C

1.				
2.				
3.				
4.				
5.				
6.				

Check-list

Check-list for evaluating desirable health environmental and sanitation habits.

Instructional focus: Obeying of safety and health rules.

Name of pupil _____

Observer _____

S. No	Criteria	Rating	
		Yes	No
1	Washes hands before and after meal		
2	Covers the mouth when coughing and sneezing		
3	Avoids spitting		
4	Urinate at proper place		
5	Uses latrine properly		
6	Does not throw garbage indiscriminately		
7	Always keeps face, eyes, nose and ears clean		
8	Trims the nails regularly		
9	Combs the hair daily		
10	Puts on clean clothes		
11	Takes bath daily		
12	Does not insert nails, pencils, etc., into nose, ears and mouth		
13	Does not drink dirty water		
14	Prevents contamination of food from flies and dust		
15	Does not eat uncovered food		

Oral test

Oral test on observation

- 1 What is the name of your school?
- 2 Are there extra rooms other than your classroom?
- 3 On what does your teacher write while teaching?
- 4 Name five living and five non-living things in the school.
- 5 Of what material is your school walls made of?

4.6 Evaluation of problem solving – some examples

To solve a given problem, a learner has to use certain ideas and skills. From the point of view of evaluation, it is vital that these are carefully identified and documented, so that the extent to which they have been used successfully can be evaluated. For the purposes of grading and assessing progress, a series of statements in terms of what learners will or will not be able to do at each stage, should be needed. Each stage can be assigned a mark.

Possible developmental stages and investigative skills to be assessed

SKILL 1: Using and organising techniques, apparatus and materials

Stage 1: Can follow written, oral or diagrammatic instruction to carry out one operation; needs help to do more; uses familiar apparatus adequately, but needs showing how to use unfamiliar apparatus; rather thoughtless over safety points.

Stage 2: Can follow written, oral or diagrammatic instruction to carry out an operation involving a series of steps and uses familiar apparatus adequately and safely; needs demonstration of how to use unfamiliar apparatus.

Stage 3: Can follow written, oral or diagrammatic instruction to carry out an operation involving a series of steps and is able to modify the instructions to improve the operation of the equipment; uses familiar apparatus adequately and safely; can make a fair attempt at using unfamiliar apparatus.

SKILL 2: Observing, measuring and recording

Stage 1: Can follow detailed instructions to make observations; can make simple measurements using a simple measuring device; records results in an appropriate way when shown how to do so.

Stage 2: Makes measurements, given a brief outline of how to do it; can use some more complex measuring devices such as those having a scale where 1 division is equal to 0.1 of unit or 2 units; reads most devices but may not do so with complete accuracy; records results in an appropriate way given an outline format.

Stage 3: Makes relevant observations that are as accurate as possible; can read any scale correctly; records results correctly without being given a format.

SKILL 3: Handling experimental observations and data

Stage 1: Can process results adequately given detailed instructions on how to do it; can draw one obvious conclusion from the results.

Stage 2: Can process results adequately given outline instructions on how to do it; can recognise results that might have experimental errors; can draw conclusions from the data.

Stage 3: Can process results adequately without help, recognises experimental errors and knows how to deal with them; can identify possible reasons for the error; can draw conclusions; and also makes general deductions from data.

SKILL 4: Planning and investigating

Stage 1: Can suggest a simple experiment to investigate a practical problem, although this may not work; can attempt modifying the experiment if it does not work.

Stage 2: Can list a series of steps to carry out an investigation; can modify the steps that do not work well; can recognise the need to control variables though may not be very clear about how to do it systematically.

Stage 3: Can list a series of logical steps to carry out an investigation that is likely to work in practice; modifies the steps that do not work well; recognises the need to control variables in a systematic way.

Evaluation of individuals in group work

4.7

Most evaluation in science and technology education is carried out by teacher educators, but teacher trainees can be good evaluators of each other especially when they work in a group on an activity. An example of how an individual in the group work can be evaluated is given below.

An innovative teaching in a school came up with an interesting approach to evaluating group work.

An overall point (percentage) grade is awarded for the activity or assignment of the group of the learners as a whole. The members of the group then decide how the marks should be distributed amongst themselves, according to the contribution each made to the work. The total marks for individual learners must, in the end, equal the mark the teacher gave to the group. If they feel they all contributed equally, they can each earn the same percentage. According to the teacher, this strategy works very well. Within a group, each individual learner knows very well who did the work or who was just sitting around!

4.8 Record keeping

Information processing is part and parcel of tools and techniques of evaluation. How information is processed is reflected in the design of tools and organising techniques of evaluation. Judgement formation and decision making will be possible through good and proper record keeping.

There are many different ways to keep records of learners' achievements and progress. The nature of the record depends to a large extent upon the technique used to collect information. For example, the record of an observation tends to be descriptive, giving information on the absence or presence of the trait being observed. Similarly, the record of a written test tends to be numerical. The type of record to be maintained also depends upon the purpose or use of the record. In general, a numerical record is not useful if one wants to know what learners can or cannot do. But if the purpose is grading the learners, then a numerical record is more useful than the descriptive record.

During formative evaluation, most of the information gathered is interpreted and used immediately for taking corrective measures in the learning activities of individual learners and for planning future activities. A record of the stages of development reached by the learner can be very useful in deciding long-term activities.

A common practice is to prepare a list of activities and tick them off as individual learners complete them. This kind of record is not very helpful since it does not tell the teacher what the learner can or cannot do. To improve the usefulness of such a list, a 'remark' column can be added where the skills observed/achieved could be written. Alternatively, a list of possible skills to be assessed could be drawn up, and for each learner the particular skills observed/achieved ticked off.

4.9 Profiles

A profile is a method of building up a picture of attainment that allows separate grades, scores, marks and other measures to be recorded for each learner. The picture can be broadened by including factors such as attitudes, health data(cleanliness), punctuality, co-operation, truthfulness, absenteeism and self-esteem. These additional attributes can be judged on, say, a 3- or 5-point scale.

Profiles can be of two types:

- An extension of the conventional evaluation data, in the sense that learner performance is reported on a large number of dimensions.
- Information presented as a record of the learner's abilities, skills and attitudes, which are explicitly stated and which describe the learner's characteristics and attributes on a criterion-referenced basis.

In the first type of profile, the data obtained from examinations is put forward as a kind of report. The data are presented in greater detail in the sense that greater numbers of subdivisions are included. But the data themselves are still either the percentage scores, or the percentages related to a 3- or 5-point scale, which may be numerical or labelled, for example, 'above average', 'average', 'below average'. When the middle grade is labelled as 'average' (average for the learner population), the profile is said to be based on norm-referenced evaluation.

Developing criterion-referenced profiles

4.9.2

If adequate information is given about the learners, the profile system mentioned above can be meaningful. But in the absence of such data (which is often the case), more meaning is attached to the profile by including the specific criteria against which measurements are taken. There is however a tendency for the profiles to be based on criteria and be related to criterion-referenced evaluation.

Relationship with fellow learners

- 4 A leader/dominant personality
- 3 Accepted member of learner groups
- 2 Likes to join with other learners, a follower
- 1 Independent, quite isolated; tends to be on his/her own

Ability to work with others

- 4 Works well as the leader of a team
- 3 Works well as a member of a team
- 2 Prefers to work on his/her own
- 1 Does not fit in well as a member of a team

Punctuality in the last year of school

- 3 Excellent
- 2 Some lateness
- 1 Poor

Regularity in the last year of school

- 1 Excellent
- 2 Some absenteeism
- 1 Poor

Discipline

- 4 Self-discipline – able to relate to a normal adult/child, teacher/learner situation
- 3 Accepts a specified pattern of behaviour and rules
- 2 Accepts an imposed pattern of behaviour and rules where there is a degree of supervision
- 1 Does not always accept a pattern of behaviour required by the learner group.

In a criterion-referenced profile, the numbers represent a 5-point range, with 5 being a high proficiency and 1 a low proficiency rating. The numbers could be easily substituted by grades or use could be made of other systems. For example the ability to use a scientific instrument could be graded as:

- 5 = can use a scientific instrument accurately and safely;
- 4 = can use a scientific instrument, with guidance, and is aware of safety aspects;
- 3 = can use a scientific instrument, with guidance, but is not aware of safety aspects;
- 2 = can not use a scientific instrument, even after guidance, but is aware of need for safe practice;
- 1 = cannot use a scientific instrument, even after guidance, and does not consider safety aspects.

4.9.3 Problems with profiling

There are three main problems associated with the profiles as a method of record keeping:

- the time it takes to develop and maintain the profile;
- the type of profile to be designed and the qualities to be described in them;
- the technical aspects of the educational measurement on which the profile is to be based, including validity and reliability.

The type of profile developed depends on the needs of the end-user.

Profiles are usually developed to show what a learner can achieve. It is a record of achievement and attitudes. The technical aspects of the profile are to do with the development of levels that show gradations in academic achievement or attitudinal development. The acceptability or validity of the profile depends on how meaningful the statements being made are to the end-user.

Profiles can be extended beyond characteristics that relate to cognitive ability or practical skills. The example below shows part of a profile covering aspects of attitude. Again, a criterion-referenced format is being followed.