AFFECTIVE SCIENCE TEACHING

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One of the chief goals of science curriculum development projects has been to stimulate student interest in science. This is one aspect of affective science teaching.

A number of dimensions in affective science teaching can be distinguished:

1. attitudes to science (involving like vs dislike of science or scientists);
2. attitudes in science (often called "scientific attitudes");
3. attitudes to the "attitudes in science".

What is the role of each of these dimensions? What emphasis should these dimensions receive in a science curriculum? What guidelines does the literature provide in these areas? The paper will examine these issues and the possible usefulness of a taxonomy for the affective domain of science education.
AFFECTIVE OR NOT?

How can science teacher educators ensure that student teachers emerge from their training (or education) programme full of enthusiasm for science and science teaching?

One approach is to write behavioural objectives in the affective domain and then grade student teachers on how well they achieve them. Objectives can include:

- The student will attend the class 90% or more of the time.
- The student will enjoy doing science. During the course of the week random observations of the student by the teacher will reveal that the student is smiling 80% of the time.
- The student will express a positive attitude toward the learning and teaching of science. On an attitude survey the student will check "agree" to those items identified as positive by the teacher, and check "disagree" to those items identified as negative.

These objectives correspond to the "receiving", "responding" and "valuing" levels of Krathwohl's (1964) taxonomy.

If students realise that they will be graded on these objectives, they will make every attempt to achieve them in the same way that they attempt to achieve pre-specified cognitive objectives of a programme.

The approach described above has been recommended (and used) by Geisert (1977). Before science teacher educators adopt this approach enthusiastically it is worthwhile examining some of the issues involved in the affective domain of science teaching.

You will have realised by now that the title of this paper is "affective" science teaching, not "effective" science teaching. This paper addresses the first of these two difficult areas of research.

A CHANGE IN EMPHASIS

Many of the first "wave" of curriculum development projects in science emphasised cognitive objectives almost exclusively. This emphasis was also present in the secondary science curricula in all Australian states: the chief objective was (in general) the acquisition of knowledge. The emphasis is now shifting.
The science curriculum in years 8-10 in this state, for example, aims at developing in students an inquiring attitude, appreciation of the contributions of scientists, awareness of the impact of science on society as well as acquiring knowledge in the various science disciplines (Education Department, 1974).

The Australian Science Education Project (ASEP), a national science curriculum project, also illustrates the curricular emphasis on non-cognitive objectives. Important aims of the project are the development in children of both skills and attitudes important in a science investigation, as well as an understanding of (and concern for) the consequences of science and technology. Some of the skills ASEP materials aim at developing are: observing; ordering observations; detecting patterns and relationships. Among the attitudes objectives are the development of a predisposition to: demand evidence in support of claims, be persistent when faced with difficulties; admit to error; be critically tolerant of the opinions of others (Australian Science Education Project, 1974).

THE AFFECTIVE DOMAIN

That there are three domains in education (cognitive, affective and psychomotor) is now part of educational dogma. This tripartite division of the educational enterprise has been criticised (particularly by philosophers) as an artificial distinction which bears no relationship with reality.

The three-fold classification remains, nevertheless, a useful distinction for curriculum workers. It serves to sensitize teachers and others working in the curriculum field of the importance of non-cognitive objectives.

The publication of Bloom's (1956) taxonomy of cognitive objectives foreshadowed a classification of objectives in the other two major educational domains: affective and psychomotor. The affective taxonomy, however, was not published till almost a decade later (Krathwohl, 1964).

In the meantime, curriculum developers in science (and other subject areas) used the taxonomy to provide detailed lists of objectives in the cognitive domain. It is true that the cognitive taxonomy stimulated
the development of an array of objectives other than the low-order knowledge objectives which had previously dominated curricula. The well-explored but generally unproductive valley of knowledge objectives gave way to broad vistas of comprehension, application, synthesis and evaluation objectives.

Bloom's taxonomy produced well-defined cognitive behaviours which are amenable to evaluation. Technological societies demand skills with concepts and symbols. A variety of teaching strategies is available for producing these cognitive skills. The cognitive taxonomy had, therefore, an immediate impact on the curriculum.

The taxonomy of affective objectives has not had the same impact as its predecessor. There are a number of reasons for this, including some ethical concerns which have been discussed elsewhere (Schibeci, 1977). To ignore affective objectives in science teaching, however, has serious implications. A science programme barren of affective objectives is not likely to appeal to the great majority of students who will not be pursuing tertiary careers.

For science teachers, the affective domain in science education can be fruitfully subdivided into three dimensions:

1. Attitudes to science;
2. Attitudes in science;
3. Attitudes to the "attitudes in science".

Attitudes to science involve like or dislike of science, a particular science, scientists or the activities of scientists. Interest, enjoyment and satisfaction are best subsumed under this dimension. These attitudes can be described as affectively-oriented because of their emphasis on emotions and feelings.

Attitudes in science are often called "scientific attitudes". Traits which scientists are supposed to display in their work (such as open-mindedness, curiosity and willingness to suspend judgement) can be labelled "attitudes in science". These can be described as cognitively-oriented attitudes, because of their intellectual emphasis.

Attitudes to "attitudes in science" refer to the attitudes displayed by students to the scientific attitudes mentioned above. Do students perceive these attitudes as essential to the scientific enterprise? Does the "scientific" approach to problem-solving appeal to them as a way of solving some everyday problems?
THE LITERATURE

A number of reviews of the literature on attitudes (in science education) have appeared: Aiken and Aiken (1969), Gardner (1975) and Ormerod and Duckworth (1975). This section of the paper will highlight some of the significant trends revealed by the literature.

(a) Attitudes to Science

Science teachers, in common with the community generally, would regard attitudes informally as feelings for or against. This corresponds to what has been labelled "attitudes to science".

The psychological literature on attitudes is vast (e.g., Triandis, 1971; Wiechman and Wiechman, 1973). One approach to the conceptualisation of attitudes explores three facets of attitudes: the cognitive, affective (emotional) and behavioural aspects. Shaw and Wright (1967) suggest that it is best to focus on the emotional aspect - this is consistent with the views being developed on this paper.

What variables have been shown to influence attitudes? Sex is one such variable. Gardner (1974) has reviewed the literature on sex differences and attitudes to science. He concluded that boys show a much more favourable attitude to science than girls, particularly in primary schools. These differences are less marked in high school when science becomes an option. Girls show a preference for the biological sciences, while boys prefer the physical sciences.

Another variable which has also been linked with attitudes is perceived subject difficulty. Duckworth and Entwistle (1974), for example, examined students' subject choice in Britain and concluded that the "swing from science" was in fact, a swing away from subjects which were perceived as difficult. The larger number of less academically able students entering the English sixth form has resulted in a greater proportion of students choosing subjects (such as English and geography) which were perceived to be "easy" (Entwistle and Duckworth, 1977).

The curriculum is a third variable which has been investigated for its possible influence on attitudes. For example, Milson (1973) designed a science curriculum for slow learners. In a carefully designed experiment, he found that the experimental group showed a significant improvement in attitude to the science class and science laboratory. Other studies of the curriculum variable - for example, Choppin's (1974) study of Nuffield science projects in England and Wales - are less encouraging. A constant source of difficulty in such studies is to
distinguish unambiguously between (for example) "Nuffield" chemistry and "non-Nuffield" chemistry in the classroom.

One of the most thorough studies on the influence of the curriculum on a number of other variables (including attitudes) was the evaluation of the Harvard Project Physics (Welch and Walberg, 1972). The most important conclusion (in terms of this paper) was that the attitudinal goals of the course were achieved without loss of physics achievement.

A variable which has been shown to influence attitudes is the teacher: As mentioned above, the teacher variable is often a confounding variable in studies which compare curriculum "X" with curriculum "Y". A variety of strategies are used by teachers in both groups; it is often difficult (if not impossible) to identify "X" or "Y" uniquely.

A short investigation carried out by the author (Schibeci, 1977) forcefully brought home the point that the teacher is a more important variable than the curriculum. Six year 10 science classes in a large metropolitan high school were involved in the investigation. Two of the classes used innovative chemistry curriculum materials; the other four classes pursued the predetermined Year 10 science programme. Two of these four classes were collapsed before the investigation was complete. The attitudes of students in these two classes toward a number of concepts (including chemistry, science, science teacher, school and science class) improved, no matter who their new teacher was!

Many other variables have been investigated for their influence on attitudes: creativity, class sizes, the grading practices of teachers, intelligence and a variety of others. The evidence of the influence of these variables on attitudes is (when not contradictory) generally inconclusive.

(b) **Attitudes in Science**


Cohen (1971) reviewed the literature on attitudes in science and gathered a list of 230 distinct statements which could be regarded as "scientific attitudes". Which of these are crucial to the scientific enterprise? Cohen approached the problem empirically by asking fifty-eight members of the Australian Academy of Science to rate each of the statements
from 1 ("least essential component of the scientific attitude") to 9
("most essential component of the scientific attitude ").

There was consensus on thirty of the 230 statements only. Perhaps
the most interesting result of this study was the finding that these were
as many scientists who regarded belief in superstition or good-luck
charms and appeal to the supernatural as an essential component of
the scientific attitude as rejected this view. Curriculum developers
in science do not include this component of the scientific attitude!

Gauld (1973) has argued that the progress of science would have
been hindered if scientists were controlled by these attitudes. He
argues that these attitudes represent neither the characteristics of
scientists nor the nature of scientific work. Westfall (1973), for
example, presents evidence that Newton was not completely honest in
his work; Cohen's (1971) study indicates that a number of clear, unique
attitudes are not necessarily crucial to the scientific enterprise.

The "attitudes in science" discussed in this section can be
fruitfully regarded as norms which govern scholarly pursuits. The work
of scientists can be checked by fellow scientists: fraud can thus be
detected - as happened recently in the case of some biochemical research
(Muller, 1977). The possibility of exposure exerts pressure on scientists
(and other scholars) to be honest, open-minded and critical.

How can these "attitudes in science" be assessed? Recently, Kozlow
and Nay (1976) have developed an instrument to measure these attitudes.
The instrument consists of forty multiple choice questions designed
to assess eight attitudes in science: critical-mindedness, suspended
judgement, respect for evidence, honesty, objectivity, willingness to
change opinions, open-mindedness and questioning attitude. A behavioural
description for each of the eight scientific attitudes is provided. An
honest student, for example, would: report observations even when they
contradict his hypothesis; acknowledge the work of others; consider all
available evidence.

This kind of approach to measurement of scientific attitudes is
appealing because of its simplicity and hence ready applicability to
the classroom. There remains, of course, the problem that students
could choose responses they thought the teacher thought desirable, rather
than the response they actually believed in. This approach to the measure-
ment of attitudes in science remains, nevertheless, the most fruitful to
date.
(c) Attitudes to "Attitudes in Science"

How do students view the "attitudes in science"? Do they perceive these attitudes as helpful in solving everyday problems?

Gauld (1976) has examined the arguments that these attitudes should be cultivated because they help students to arrive at rational, objective conclusions. In particular, he examines the usefulness of the attitudes: scepticism, open-mindedness and deliberate suspension of judgement.

He argues that it is often unrealistic to expect students to make informed choices: for example, the evidence linking smoking and lung cancer is quite technical and incomprehensible to students (and most teachers). In such a case, a student will probably accept (or reject) the authority of scientists, rather than examining directly evidence for or against smoking. (A more topical example is the issue of uranium mining. Can students be expected to make informed choices about what are essentially technical matters? Should they accept an authority they trust?)

What Gauld is basically arguing is that the precise nature of these attitudes needs to be carefully analysed before any attempt to include them in the curriculum. What is needed (he continues) is a sympathetic classroom atmosphere where students can hold convictions but where they are encouraged to examine these beliefs. One approach to this is the value clarification procedure devised by Raths, Harmin and Simon (1966). This approach has been used mainly in the social sciences, but more recently has been used in science classrooms. Gennaro and Glenn (1975), for example, have described the use of this approach with a group of science and social studies teachers.
A TAXONOMY

A taxonomy for the affective domain in science education has been recently devised by Klopf er (1976). He has produced a two-dimensional table of specifications, or grid. One of the dimensions is a list of student behaviours based on Krathwohl's (1964) taxonomy: receiving, responding, valuing, organisation, characterisation by a value complex; the second dimension is a list of "phenomena": events in the natural world, activities, science and inquiry (Figure 1).

Affective objectives can be located in cells of this grid. Examples given by Klopf er include:

- The student develops a keen interest in his or her surroundings (B.3, 1.1).
- The student enjoys his or her work in the science laboratory (B.3, 2.2).
- The student accepts the learning of science as beneficial to himself/herself (A.2, 3.11).
- The student feels a sense of kinship with people who are scientists (C.1, 3.4).
- The student views problems in objective, realistic and tolerant terms (E.1, 4.3).

The coordinates in brackets serve to locate the objective on the grid in a way analogous to the content/skills grids used to ensure that items in a test adequately sample the universe of possible items.

This taxonomy represents a useful theoretical approach to objectives for affective science teaching. If this taxonomy is to be used in grading students, on the other hand, then care is required. It has been argued elsewhere (Schibeci, 1977) that these are ethical problems associated with the assessment of an individual's attitudes to science. There may be little quarrel with the assessment of "attitudes in science", if these are considered important to scientific enterprise. To gather data on individual's attitudes may be an invasion of his privacy - particularly when the results are to be used in grading. It is preferable to gather group data on attitudes to science, unless particular students consent to have their attitudes assessed.

In terms of Klopf er's taxonomy, individual students' achievement of objectives in cells under "receiving" (A.1, A.2, A.3) could be assessed and used for grading. The remaining objectives are more profitably used to develop items for tests which would provide group data. A teacher
<table>
<thead>
<tr>
<th>PHENOMENA</th>
<th>A.O RECEIVING</th>
<th>B.O RESPONDING</th>
<th>C.O VALUING</th>
<th>D.O ORGANIZATION</th>
<th>E.O CHARACTERIZATION BY A VALUE COMPLEX</th>
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<tbody>
<tr>
<td></td>
<td>Awareness</td>
<td>Willingness to</td>
<td>Sequences</td>
<td>Satisfaction in</td>
<td>Acceptance of a Value</td>
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<td></td>
<td></td>
<td>Receive</td>
<td>Selected</td>
<td>Responding</td>
<td>Commitment</td>
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<td>A.1</td>
<td>A.2</td>
<td>A.3</td>
<td>B.1</td>
<td>B.2</td>
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<td>A.2</td>
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<td>A.3</td>
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<tr>
<th>EVENTS IN THE NATURAL WORLD</th>
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<tbody>
<tr>
<td>1.0</td>
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<td>1.1 Biological events</td>
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<td>1.2 Physical events</td>
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<tr>
<th>ACTIVITIES</th>
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<tbody>
<tr>
<td>2.0</td>
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<tr>
<td>2.1 Informal (generally outside of school)</td>
</tr>
<tr>
<td>2.11 Science activities</td>
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<tr>
<td>2.12 Science-related activities</td>
</tr>
<tr>
<td>2.2 Formalized science-learning activities in school</td>
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<tr>
<th>SCIENCE</th>
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<tr>
<td>3.0</td>
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<tr>
<td>3.1 Science as a source of knowledge about the natural world</td>
</tr>
<tr>
<td>3.11 Science in general</td>
</tr>
<tr>
<td>3.12 Any content area in science</td>
</tr>
<tr>
<td>3.2 Science as an enterprise organized to gain understanding of natural world</td>
</tr>
<tr>
<td>3.3 Science in its interrelationships with society</td>
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<td>3.4 Scientists as people</td>
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<tr>
<th>INQUIRY</th>
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<tr>
<td>4.0</td>
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<tr>
<td>4.1 Processes of scientific inquiry</td>
</tr>
<tr>
<td>4.2 Scientific inquiry as a way of thought</td>
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<tr>
<td>4.3 Inquiry as a way of thought</td>
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<tr>
<td>4.31 In association with phenomena and problems in science</td>
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<tr>
<td>4.32 In association with phenomena and problems not in science</td>
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Figure 1: A structure for the affective domain in relation to science education. (Klopfner, 1976, p.302).
would then be in a position to gather feedback on his or her affective
teaching strategies, but would not use this information to grade
students.

It should be mentioned that some would argue that if we are
justified in assessing the achievement of cognitive objectives, we ought
to be justified in assessing affective objectives as well. This argument
is consistent with a particular view of man and education, and is used
by Geisert (1977) to justify the coercive use of affective objectives.

This argument is difficult to sustain. There is wide agreement
on cognitive objectives for a science curriculum; the strategies used to
achieve them can often be clearly specified, and the techniques for
assessing achievement of these objectives well researched. None of this
is true for the affective domain.

The thesis presented in this paper is that there is a limited range
of affective objectives which can be assessed and used for grading
purposes. There is a wider range of objectives which can also be
assessed, but ought not be used for grading purposes - this wider
group of objectives can provide the teacher with group data on the impact
of affective science teaching.

APPLICATION

Why have teachers in the past ignored affective objectives?
This neglect reflects, no doubt, the past emphasis on the cognitive domain.
Teachers are now, however, provided with broadly-based affective objectives.
Klopfer's (1976) taxonomy provides a useful framework for guiding the
formulation of more precise objectives - just as Bloom's (1956) taxonomy
provided a useful framework for the formulation of more precise cognitive
objectives.

Student teachers could be given the opportunity to prepare lists
of objectives (cognitive and affective) for curriculum units. The
difficulties associated with the assessment of affective objectives
(particularly those associated with validity) need to be carefully pointed.
However, teacher-made instruments (whether of the Likert-type, semantic
differential or other type) can be used to provide general feedback rather
than quantitative measures.
Use of Klopfer's taxonomy should also serve to lift teacher's awareness of an important dimension of the scientific enterprise - teachers may even come to respond and value this systematic analysis of the affective area.

PROSPECTS

There is no disagreement amongst science educators that the affective domain is important. Science teacher educators need to provide their student teachers with the conceptual tools with which to approach affective science teaching. Classroom practice may then reflect the importance of the affective domain.
References


