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INTRODUCTION

Test of Science-Related Attitudes (TOSRA) is designed to measure seven distinct science-related attitudes among secondary school students. These scales are called Social Implications of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science. The seven scales are suitable for group administration and all can be administered within the duration of a normal class lesson. Furthermore, TOSRA has been carefully developed and extensively field tested and has been shown to be highly reliable.

This Handbook describes the development of TOSRA and includes statistical information for Year 7–10 samples. The Handbook's appendices contain instructions for administration and scoring (Appendix I) and a table indicating how the items in TOSRA are allocated to the seven different scales (Appendix II).

The present Handbook is published in conjunction with three other separate items. First there is a test master set which can be used to make reusable copies of the TOSRA test booklet. In fact, copyright exceptions permit, after initial purchase, reproduction of unlimited copies of TOSRA within an institution. Second, there is a transparent hand Score Key to facilitate convenient hand scoring of students' responses to TOSRA. Third there is a student Answer Sheet which is designed so that it can be scored using the Score Key.

TOSRA can be used by teachers, curriculum evaluators, or researchers to monitor student progress towards achieving attitudinal aims. Although it is possible to use TOSRA for assessing the progress of individual students, TOSRA is likely to be most useful for examining the performance of groups or classes of students (e.g. in curriculum evaluation). Furthermore, as well as providing information about attitudes at a particular time, TOSRA could also be used as a pre-test and a post-test (perhaps over the time of a school term or year) to obtain information about changes in attitudes.

Feedback on the Use of TOSRA

Since publication of an article describing TOSRA (Fraser, 1978), requests for copies of the test have been received from researchers and teachers in different developed and developing countries. Many of these people have used or currently are using TOSRA for their own research or teaching purposes. It would be appreciated if researchers and teachers using TOSRA in the future for various purposes would send their comments and validation data to the author at School of Education, Macquarie University, North Ryde, NSW, 2113, Australia.

BACKGROUND

Currently the promotion of favourable science-related attitudes is considered in many countries to be one of the most important aims of science education. The prominence given to attitudinal aims is reflected in the overseas curriculum packages reviewed by Hurd (1970), in the stated aims of the Australian Science Education Project (ASEP, 1974) and in science syllabuses in various Australian States. Furthermore, the assessment of attitudes is perceived as a common problem among science teachers in different parts of Australia, according to both a survey involving a national sample of 1004 ASEP teachers (Owen, 1977) and reports delivered by science educators from each Australian State and Territory (Curriculum Development Centre, 1977).

While there is considerable consensus of opinion that the promotion of favourable attitudes to science is an important aim of science education, there is confusion about what meaning should be placed on the 'attitude to science'. Klopfer (1971), however, has alleviated the semantic problems associated with the multiple meanings attached to the term 'attitude to science' by providing a comprehensive classification scheme for science education aims in which six conceptually different categories of attitudinal aims are distinguished. These six categories, which are listed in Table 1, involve distinctions between attitudes to science and scientists (H.1), attitude to inquiry (H.2), adoption of scientific attitudes like curiosity and open-mindedness (H.3), enjoyment of science learning experiences (H.4), interest in science apart from learning experiences (H.5), and interest in a career in science (H.6).

SCOPE OF TOSRA

Table 1 shows the name of the seven scales contained in TOSRA, together with the classification of the aim measured by each scale according to Klopfer's scheme. This table indicates that, while two separate TOSRA scales have been included to measure two separate aims in category H.1, each of the other five TOSRA scales measures aims in one of the remaining categories, namely H.2 to H.6.

Since category H.1 (Manifestation of favourable attitudes towards science and scientists) embraces two somewhat distinct sub-categories, namely manifestation of favourable attitudes towards science and manifestation of favourable attitudes towards scientists, a separate measure of each was included in TOSRA. However, although both of these sub-categories cover a range of related attitudes, the test battery was restricted to a reasonable size by including a measure of a single aspect of each sub-category. The Social Implications of Science scale in TOSRA
Table 1  Name and Classification of Each Scale in TOSRA

<table>
<thead>
<tr>
<th>Scale name</th>
<th>Klopfer (1971) classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Implications of Science (S)</td>
<td>H.1: Manifestation of favourable attitudes towards science and scientists</td>
</tr>
<tr>
<td>Normality of Scientists (N)</td>
<td>H.2: Acceptance of scientific inquiry as a way of thought</td>
</tr>
<tr>
<td>Attitude to Scientific Inquiry (I)</td>
<td>H.3: Adoption of 'scientific attitudes'</td>
</tr>
<tr>
<td>Adoption of Scientific Attitudes (A)</td>
<td>H.4: Enjoyment of science learning experiences</td>
</tr>
<tr>
<td>Enjoyment of Science Lessons (E)</td>
<td>H.5: Development of interest in science and science-related activities</td>
</tr>
<tr>
<td>Leisure Interest in Science (L)</td>
<td>H.6: Development of interest in pursuing a career in science</td>
</tr>
<tr>
<td>Career Interest in Science (C)</td>
<td></td>
</tr>
</tbody>
</table>

measures one aspect of manifestation of favourable attitudes towards science which has been afforded importance in the science education literature (Zoller and Watson, 1974; Fraser, 1977a), namely attitude towards the social benefits and problems which accompany scientific progress. The Normality of Scientists scale in TOSRA measures one aspect of manifestation of favourable attitudes towards scientists given prominence in science education, namely an appreciation that scientists are normal people rather than the eccentrics often depicted in the mass media (Mead and Métraux, 1957; Fraser, 1977b).

The third scale listed in Table 1, the Attitude to Inquiry scale, measures attitude to scientific experimentation and inquiry as ways of obtaining information about the natural world; this attitude is similar in meaning to category H.2. The fourth scale in TOSRA, the Adoption of Scientific Attitudes scale, measures an attitudinal aim identical in meaning to category H.3. Furthermore a major merit of this scale is that the specific attitudes (e.g. open-mindedness, willingness to revise opinions, etc.) included as desirable ones were selected from those consistently rated by a group of eminent Australian scientists as being of considerable importance in their work as scientists (Cohen, 1971; 1972). The meaning of the aims measured by the last three scales listed in Table 1 is identical to the meaning of categories H.4 to H.6 and is reflected in the titles of these three scales, namely Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science.

The nature of the aim measured by each scale in TOSRA can be further clarified by examining the actual items in each scale. Appendix II indicates which items fall into each of the seven separate scales.

**RESPONSE FORMAT OF TOSRA ITEMS**

TOSRA items involve a response format, first described by Likert (1932), which requires students to express their degree of agreement with each statement on a five-point scale consisting of the responses Strongly agree (SA), Agree (A), Not sure (N), Disagree (D) and Strongly disagree (SD). Scoring involves allotting 5, 4, 3, 2, 1 for the responses SA, A, N, D, SD, respectively, for items designated as positive (+) in Appendix II and allotting 1, 2, 3, 4, 5 for the responses SA, A, N, D, SD, respectively, for items designated as negative (−).

An important feature of Likert-type items is that their intention is often obvious to the test respondent and, therefore, it is possible for the respondent to fake responses to reflect opinions which are more positive or more negative than they really are. In interpreting student responses to TOSRA, therefore, the possibility of faking responses to some items cannot be completely overlooked. Consequently, like most attitude tests, TOSRA is of limited usefulness for the purpose of grading individual students, since students could fake answers to improve their grades. However, as long as TOSRA is not used for grading, there would be little point in students faking responses and reasonable confidence could be placed in student responses. In fact, faking of responses is likely to be minimized if the teacher makes it clear to students that results are not for grading. Moreover, in cases where information is required about groups rather than individuals, the likelihood of faking could be further reduced by making responses anonymous.
ADMINISTRATION AND SCORING

For easy reference, the instructions for administration and scoring of TOSRA have been placed in Appendix I at the back of this Handbook. Scoring can be accomplished by computer or by using the transparent hand Score Key provided.

PREVIOUS BATTERY OF FIVE ATTITUDE SCALES

TOSRA is an extension of a previous battery of attitude scales containing earlier versions of the following five TOSRA scales: Social Implications of Science, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons and Leisure Interest in Science. However, as the development and validation of the earlier battery of five scales have been discussed at length elsewhere (Fraser, 1977c), only the three main stages in the development are mentioned briefly below. First a version of each scale was assembled, based on existing instruments and reactions from science teachers and experts in educational measurement about each item's clarity, readability, face validity, and scale allocation. Second a revised version was assembled, based on evidence from analysis of data collected during the field testing of the first version of the scales with a sample of 165 Year 7 students in Melbourne. Third the revised version of each scale was field tested with a large sample of 1158 Year 7 students in Melbourne and was shown to have satisfactorily high reliability.

DEVELOPMENT OF TOSRA

The previous battery of five attitude scales was extended and improved in four ways to form TOSRA. First two new scales, Normality of Scientists and Career Interest in Science, were added. Second, whereas the previous battery involved three different sets of administration instructions and answering formats, TOSRA was designed with a single set of instructions and answering format. Third, while different scales in the previous battery contained different numbers of items, TOSRA was designed with the same number of items (namely 10) in each scale in order to facilitate ready comparison between performance on different scales. Fourth, whereas the original battery was field tested and validated using only samples of students at the Year 7 level, the field testing and validation of TOSRA involved students at all four junior high school grade levels (Years 7-10).

The final form of TOSRA was obtained after refining preliminary versions in two successive stages. The first stage involved modifying a pool of items in the light of reactions solicited from a group of science teachers and experts in educational measurement. The second stage involved the field testing of a version of TOSRA containing 14 items per scale and the subsequent use of the item analysis techniques described in Fraser (1977c) to reduce the length of each scale to 10 items.

STATISTICAL INFORMATION FOR YEARS 7–10

A version of TOSRA was administered during 1977 to a large sample of students in the Sydney metropolitan area at the Year 7–10 level. Statistical analyses were performed on these data in order to identify certain items which could be deleted from the battery in order to reduce the length of each scale to 10 items and to enhance the overall scale characteristics. Then, for each refined scale containing 10 items, the following four scale statistics were calculated: mean, standard deviation, reliability, and scale intercorrelation.

Samples

Table 2 describes the sample involved in the field testing of TOSRA at each level. This table indicates that the total sample consisted of 1337 students in 44 classes drawn from 11 different schools. In fact, each of the 11 schools provided a typical and comparable class, one each at the Year 7, 8, 9 and 10 level. The reason for drawing only one class at each grade level from a single school was to involve the broadest spectrum of schools possible for a given sample size, while the reason for drawing the sample at each grade level from the same set of schools was to enable meaningful comparison between statistics at different grade levels. Table 2 shows that the sample size was 340 in Year 7, 335 in Year 8, 335 in Year 9, and 324 in Year 10.

The sample of schools, although not randomly chosen for a variety of reasons, was carefully selected to cover a variety of socioeconomic and geographic areas and to be representative of the population of schools in the Sydney metropolitan area. The 11 schools in the sample consisted of five coeducational government high schools, two single-sex government high schools (one boys and one girls), two independent Catholic schools (one boys and one girls), and two independent non-Catholic schools (one boys and one girls). The sample at each level contained approximately equal numbers of boys and girls.
Table 2 Sample Sizes for Years 7–10

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of classes</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>11</td>
<td>340</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
<td>335</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>338</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>324</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>1337</td>
</tr>
</tbody>
</table>

a One class at each level was drawn from a different school.

Means

Table 3 shows, separately for each level, the mean score on each of the seven TOSRA scales and the overall mean of the seven scale means. The possible score range on each scale is from a minimum of 10 to a maximum of 50. The results in Table 3 indicate that the mean score on each scale tended to be approximately similar at all four levels, although the mean score did tend to vary considerably from scale to scale. In fact, for the Year 7 sample, mean scores ranged from 27.5 for the Leisure Interest in Science scale to 40.5 for the Attitude to Inquiry scale.

Standard Deviations

The standard deviation of each scale and the mean of the seven scale standard deviations are shown separately for each level in Table 3. These values indicate that TOSRA scales generally had a reasonable spread of scores at each level. The table also shows that the standard deviation for a given scale was comparable at each level, although the standard deviation varied considerably from scale to scale (ranging from 4.5 for the Adoption of Scientific Attitudes scale to 9.5 for the Enjoyment of Science Lessons scale at the Year 7 level).

Reliability

The internal consistency reliability (the extent to which items in a given scale measure the same attitude) was estimated for TOSRA scales using the Cronbach $\alpha$ coefficient (Cronbach, 1951). Table 3 shows, separately for each level, the $\alpha$ coefficient for each TOSRA scale and the mean of the seven scale coefficients. The values of the reliability coefficient ranged from 0.66 to 0.93 with a mean of 0.82 for the Year 7 sample, from 0.64 to 0.93 with a mean of 0.80 for the Year 8 sample, from 0.69 to 0.92 with a mean of 0.81 for the Year 9 sample, and from 0.67 to 0.93 with a mean of 0.84 for the Year 10 sample. These values for the reliability coefficient are generally high for scales whose length is only 10 items, and all values are large enough to indicate that each TOSRA scale had quite good internal consistency reliability at each level.

In addition to internal consistency reliability coefficients, Table 3 contains estimates of the test-retest reliability of TOSRA scales. These calculations were based on data from a sub-sample of 238 students comprising the Year 8 and Year 9 classes in four of the schools (two coeducational government high schools, one independent Catholic girls school and one independent non-Catholic boys school) in the original sample. These students responded to TOSRA a second time approximately two weeks after the first administration. Table 3 shows that test-retest coefficients ranged from 0.69 to 0.84 with a mean of 0.78, thus indicating that all TOSRA scales displayed quite good test-retest reliability.

Discriminant Validity

Intercorrelations among TOSRA scales were calculated as indices of discriminant validity (the extent to which a given scale measures a unique attitude not measured by other scales in the battery). It was found that, for the total sample of 1337 students, TOSRA scale intercorrelations were generally fairly low and ranged from 0.10 to 0.59 with a mean of 0.33. The average correlation of each TOSRA scale with the other six scales was calculated and these values are recorded in Table 3. The table shows that the mean correlation of a given scale with the other six scales had moderately low values ranging from 0.13 for the Attitude to Inquiry scale to 0.40 for the Career Interest in Science scale.

It is noteworthy that the highest scale intercorrelations (values of 0.53, 0.58 and 0.59) occurred between the three scales of Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science. Although these three attitudes are conceptually distinct, one would generally expect them to be moderately well correlated among students since there would be a tendency for a student who enjoys science lessons to be more likely to have a leisure and career interest in science. Furthermore, as all values of the scale intercorrelation were smaller than the square root of the product of the corresponding scale reliabilities, which is the value representing perfect conceptual equivalence (Block, 1963), it was considered justifiable to maintain all seven TOSRA scales as separate dimensions.
Table 3  Mean, Standard Deviation, Reliability and Discriminant Validity (Mean Correlation with Other Scales) of Each TOSRA Scale

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean in Year</th>
<th>Standard deviation in Year</th>
<th>α Reliability in Year</th>
<th>Test-retest reliability</th>
<th>Mean correlation with other scales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 8 9 10</td>
<td>7 8 9 10</td>
<td>7 8 9 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Implications of Science</td>
<td>35.7 34.2 35.9 37.3</td>
<td>5.7 6.2 4.9 5.2</td>
<td>0.81 0.82 0.75 0.82</td>
<td>0.76 0.39</td>
<td></td>
</tr>
<tr>
<td>Normality of Scientists</td>
<td>35.6 34.3 35.8 36.3</td>
<td>5.2 5.1 4.9 4.9</td>
<td>0.72 0.70 0.72 0.78</td>
<td>0.69 0.27</td>
<td></td>
</tr>
<tr>
<td>Attitude to Inquiry</td>
<td>40.5 39.3 38.2 35.9</td>
<td>5.8 6.2 5.9 6.7</td>
<td>0.81 0.82 0.81 0.86</td>
<td>0.79 0.13</td>
<td></td>
</tr>
<tr>
<td>Adoption of Scientific Attitudes</td>
<td>38.0 37.2 37.9 38.4</td>
<td>4.5 4.5 4.5 4.2</td>
<td>0.66 0.64 0.69 0.67</td>
<td>0.75 0.33</td>
<td></td>
</tr>
<tr>
<td>Enjoyment of Science Lessons</td>
<td>32.8 29.7 31.2 33.5</td>
<td>9.5 9.6 8.9 8.6</td>
<td>0.93 0.92 0.92 0.93</td>
<td>0.78 0.39</td>
<td></td>
</tr>
<tr>
<td>Leisure Interest in Science</td>
<td>27.5 24.7 24.9 26.9</td>
<td>8.6 8.3 8.0 8.4</td>
<td>0.88 0.85 0.87 0.89</td>
<td>0.82 0.39</td>
<td></td>
</tr>
<tr>
<td>Career Interest in Science</td>
<td>28.2 26.0 26.5 28.8</td>
<td>8.2 8.2 7.8 8.4</td>
<td>0.90 0.88 0.88 0.91</td>
<td>0.84 0.40</td>
<td></td>
</tr>
</tbody>
</table>

Mean of nine scales               | 34.0 32.2 32.9 33.9 | 6.8 6.9 6.4 6.6                        | 0.82 0.80 0.81 0.84                       | 0.78 0.33                   |

Each scale contains 10 items scored from 1 to 5 so that the minimum and maximum score possible on each scale is 10 and 50 respectively.

The sample sizes at different levels ranged from 324 to 340.

α Test-retest coefficients were estimated for a sub-sample of 238 students from Years 8 and 9, drawn from the original sample.
Table 4  Cross-Validation Data from Australia and United States

<table>
<thead>
<tr>
<th>Scale</th>
<th>Alpha reliability</th>
<th>Mean correlation with other scales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NSW Years 7–10 (N=712)</td>
<td>Qld Year 10 (N=567)</td>
</tr>
<tr>
<td>Social Implications of Science</td>
<td>0.80</td>
<td>0.81</td>
</tr>
<tr>
<td>Normality of Scientists</td>
<td>0.71</td>
<td>0.69</td>
</tr>
<tr>
<td>Attitude to Inquiry</td>
<td>0.81</td>
<td>0.82</td>
</tr>
<tr>
<td>Adoption of Scientific Attitudes</td>
<td>0.62</td>
<td>0.64</td>
</tr>
<tr>
<td>Enjoyment of Science</td>
<td>0.91</td>
<td>0.90</td>
</tr>
<tr>
<td>Lessons</td>
<td>0.86</td>
<td>0.84</td>
</tr>
<tr>
<td>Leisure Interest in Science</td>
<td>0.88</td>
<td>0.85</td>
</tr>
<tr>
<td>Career Interest in Science</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CROSS-VALIDATION IN AUSTRALIA AND THE UNITED STATES

Since the initial validation of TOSRA in 1977 (see Table 3), cross-validation data have become available from administration of TOSRA to five new samples of secondary science classes in Australia and the United States. The first sample consisted of 712 Year 7–9 students from 23 different classes, each with a different teacher, in eight different schools located in the Sydney suburban area (see Fraser and Butts, in press). The next two samples consisted of 567 Year 10 students and 273 Year 12 students in four comprehensive state high schools in Brisbane (Lucas and Tulip, 1980). The fourth sample consisted of 1041 Year 8–10 students from 11 schools in suburban areas of Perth, Western Australia (Schibeci and McGaw, 1980). The fifth sample consisted of 546 Year 9 girls in two urban Catholic schools in Philadelphia (Fraser and Butts, in press).

Table 4 shows the values obtained for each TOSRA scale for the internal consistency reliability (alpha coefficient) for each of the five samples and for the discriminant validity (mean correlation with the other six scales) for the Sydney sample and the United States sample. All cross-validation data in Table 4 compare favourably with the validation data reported previously in Table 3. These results are important, not only because they provide additional support for the validity of TOSRA for use with Australian students, but also because they support the cross-cultural validity of TOSRA for use in the United States.

USES OF TOSRA

It was noted previously that TOSRA can be used by teachers or researchers to monitor student progress towards achieving attitude aims: that is, a teacher might employ TOSRA to obtain information about the science-related attitudes of individual students or, preferably, whole classes. This could be done at one particular time or could involve changes in attitudes occurring over time.

A major advantage that TOSRA has over some other science attitude tests is that it yields a separate score for a number of distinct attitudinal aims instead of a single overall score. This makes it possible to obtain a profile of attitude scores for groups of students. For example, Figure 1 makes use of the data in Table 3 to plot the profile of mean attitude scores for the sample of 1337 students involved in the field testing of TOSRA.

When attempting to interpret scores obtained on TOSRA, relative interpretations often can be more meaningful than absolute ones. For example, a comparison of an individual’s scores, or preferably a class’s mean scores, at two separate times can provide valuable information about changes occurring in student attitudes. Similarly a comparison of the attitudes of two groups of students (e.g. groups following alternative teaching methods or curriculum materials) can be illuminating.

Because of the difficulties inherent in making absolute interpretations of scores on TOSRA, it is sometimes helpful for teachers to compare the scores obtained by their students with the average scores ob-
tained by a larger and broader sample. In particular, teachers could find it helpful to compare their class’s mean scores with the means obtained by the larger sample of 1337 Year 7-10 students involved in the field testing of TOSRA. The means for the field-testing sample are recorded in Table 3 and, because students at different grade levels tended to obtain similar scores, are plotted on a grid to form the single profile shown in Figure 1.

Teachers are cautioned against being overly concerned if their students’ scores deviate from the mean profile shown in Figure 1. Nevertheless it is hoped that interpretation of the mean TOSRA scores obtained by a particular group of students might be facilitated by drawing a profile for that group and comparing it with the profile of means shown in Figure 1 for the field-testing sample. By doing this, it can be readily ascertained whether the scores for a specific group of students are above or below the means obtained by other students at the junior high school level. While differences of only one mark between scores obtained by a particular group and by the field testing sample may not be very meaningful, differences approaching one square on the grid of Figure 1 are likely to be educationally important.

To date many research workers and many more teachers have used TOSRA in a number of different countries. What feedback information is available from these users suggests that the classroom administration of TOSRA ran smoothly and that the test was found to be useful. Although it is too early yet for the appearance of many published reports describing the use of TOSRA for research purposes, several articles are already available. For example, use of earlier versions of some of TOSRA’s scales in two separate science curriculum evaluation studies has been reported by Fraser (1979) and Fisher and Fraser (1980). Also, studies of relationships between students’ science-related attitudes and their perceptions of psychosocial characteristics of their classroom learning environment have been conducted using all scales contained in the final version of TOSRA (Fraser and Butts, in press) and selected scales from an earlier version of TOSRA (Fraser, 1979; Fisher and Fraser, in press).
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Appendix I

INSTRUCTIONS FOR ADMINISTRATION AND SCORING

Time required
1 No time limit should be applied when administering TOSRA (although it is not necessary to allow exceptionally slow students to finish). The approximate time taken for instructions and answering ranges from 30-45 minutes at the Year 7 level to 25-30 minutes at the Year 10 level.

Administration
2 Instruct students not to commence writing until told to do so.
3 Hand out the tests and the answer sheets.
4 Make it clear to students that the test is not for grading purposes.
5 Go through the Directions on the first page of the test thoroughly with the class and go over the Practice Item on the chalk board.
6 Emphasize that only one response should be circled for each item, that responses are to be given on the separate Answer Sheet, and that the way to alter an answer is to cross out the old answer and then circle the new choice.
7 Answer any reasonable student queries.
8 Tell students to write their names (if required), school, and year/class designation on the Answer Sheet, and then to commence answering.
9 During testing move around the class to check that pupils are answering as instructed. Continue to answer reasonable queries but do not encourage excessive queries.
10 Students who finish early should be given something quiet to do.
11 Collect the tests and answer sheets when all, or nearly all, students have finished. (It is not necessary to allow exceptionally slow students to finish.) Ask students to check that they have filled in the details on the Answer Sheet.

Scoring
12 Appendix II shows how the 70 items in TOSRA are allocated to the seven different scales and whether each item is positive (+) or negative (−) with respect to scoring. For positive items (+), responses SA, A, N, D, SD are scored 5, 4, 3, 2, 1, respectively. For negative items (−), responses SA, A, N, D, SD are scored 1, 2, 3, 4, 5, respectively. Omitted or invalidly answered items are given a score of 3. The seven separate scale scores are obtained by adding the scores obtained on all items within a given scale. Since each scale contains 10 items, the minimum and maximum scores possible on each scale are 10 and 50, respectively. Scale scores, however, cannot be added to form a meaningful total score. For people wishing to score TOSRA by hand (rather than by computer), use can be made of the convenient hand Score Key described below.

Hand Score Key
13 Check each student’s Answer Sheet for any omitted items or invalid responses (e.g. more than one response circled). Amend each of these so that the N response is circled.
14 Place the transparent hand Score Key over the student’s Answer Sheet so that the lines ruled on the Score Key correspond with those on the Answer Sheet. The score for a particular item is simply the number on the hand Score Key which is superimposed on top of the student’s circled response.
15 Obtain the student’s score for Scale S by adding the 10 scores for the individual items in this scale. Each of the 10 items belonging to Scale S is located as the first item in each block of seven items on the Answer Sheet. Also the Hand Score Key has the letter S written on it in various places to indicate which horizontal rows contain items belonging to Scale S. The total score for Scale S can be recorded in the space provided at the bottom of the Answer Sheet.
16 Obtain the student’s total scores for the other six attitude scales by following a similar procedure, and record these scores in the spaces provided at the bottom of the Answer Sheet. Scales N, I, A, E, L and C consist, respectively, of the second, third, fourth, fifth, sixth, and seventh items in each block of seven items on the Answer Sheet. The hand Score Key contains the letters N, I, A, E, L and C to indicate which horizontal rows contain items belonging to the different scales.

Processing and Interpreting Results (Optional)
17 One of the most useful ways for teachers to process and interpret results is to calculate the mean score on each TOSRA scale obtained by a particular group of students (e.g. a class), to plot a profile of scale mean scores, and to compare this profile with that obtained for the field-testing sample (see Figure 1).
Appendix II

SCALE ALLOCATION AND SCORING FOR EACH ITEM

<table>
<thead>
<tr>
<th>S</th>
<th>Social Implications of Science</th>
<th>N Normality of Scientists</th>
<th>I Attitude to Scientific Inquiry</th>
<th>A Adoption of Scientific Attitudes</th>
<th>E Enjoyment of Science Lessons</th>
<th>L Leisure Interest in Science</th>
<th>C Career Interest in Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (+)</td>
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<td>67 (-)</td>
<td>68 (-)</td>
<td>69 (-)</td>
<td>70 (+)</td>
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</table>

For positive items (+), responses SA, A, N, D, SD are scored 5, 4, 3, 2, 1, respectively. For negative items (-), responses SA, A, N, D, SD, are scored 1, 2, 3, 4, 5, respectively. Omitted or invalid responses are scored 3.
TOSRA

TEST OF SCIENCE-RELATED ATTITUDES

Barry J. Fraser

DIRECTIONS

1. This test contains a number of statements about science. You will be asked what you yourself think about these statements. There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

2. All answers should be given on the separate Answer Sheet. Please do not write on this booklet.

3. For each statement, draw a circle around

   SA if you STRONGLY AGREE with the statement;
   A if you AGREE with the statement;
   N if you are NOT SURE;
   D if you DISAGREE with the statement;
   SD if you STRONGLY DISAGREE with the statement.

Practice Item

0. It would be interesting to learn about boats.

Suppose that you AGREE with this statement, then you would circle A on your Answer Sheet, like this:

   SA  A  N  D  SD

4. If you change your mind about an answer, cross it out and circle another one.

5. Although some statements in this test are fairly similar to other statements, you are asked to indicate your opinion about all statements.
1 Money spent on science is well worth spending.
2 Scientists usually like to go to their laboratories when they have a day off.
3 I would prefer to find out why something happens by doing an experiment than by being told.
4 I enjoy reading about things which disagree with my previous ideas.
5 Science lessons are fun.
6 I would like to belong to a science club.
7 I would dislike being a scientist after I leave school.
8 Science is man's worst enemy.
9 Scientists are about as fit and healthy as other people.
10 Doing experiments is not as good as finding out information from teachers.
11 I dislike repeating experiments to check that I get the same results.
12 I dislike science lessons.
13 I get bored when watching science programs on TV at home.
14 When I leave school, I would like to work with people who make discoveries in science.
15 Public money spent on science in the last few years has been used wisely.
16 Scientists do not have enough time to spend with their families.
17 I would prefer to do experiments than to read about them.
18 I am curious about the world in which we live.
19 School should have more science lessons each week.
20 I would like to be given a science book or a piece of scientific equipment as a present.
21 I would dislike a job in a science laboratory after I leave school.
22 Scientific discoveries are doing more harm than good.
23 Scientists like sport as much as other people do.
24 I would rather agree with other people than do an experiment to find out for myself.
25 Finding out about new things is unimportant.
26 Science lessons bore me.
27 I dislike reading books about science during my holidays.
28 Working in a science laboratory would be an interesting way to earn a living.
29 The government should spend more money on scientific research.
29 Scientists are less friendly than other people.
30 I would prefer to do my own experiments than to find out information from a teacher.
31 I like to listen to people whose opinions are different from mine.
33 Science is one of the most interesting school subjects.
34 I would like to do science experiments at home.
35 A career in science would be dull and boring.
36 Too many laboratories are being built at the expense of the rest of education.
37 Scientists can have a normal family life.
38 I would rather find out about things by asking an expert than by doing an experiment.
39 I find it boring to hear about new ideas.
40 Science lessons are a waste of time.
41 Talking to friends about science after school would be boring.
42 I would like to teach science when I leave school.
43 Science helps to make life better.
44 Scientists do not care about their working conditions.
45 I would rather solve a problem by doing an experiment than be told the answer.
46 In science experiments, I like to use new methods which I have not used before.
47 I really enjoy going to science lessons.
48 I would enjoy having a job in a science laboratory during my school holidays.
49 A job as a scientist would be boring.
This country is spending too much money on science.

Scientists are just as interested in art and music as other people are.

It is better to ask the teacher the answer than to find it out by doing experiments.

I am unwilling to change my ideas when evidence shows that the ideas are poor.

The material covered in science lessons is uninteresting.

Listening to talk about science on the radio would be boring.

A job as a scientist would be interesting.

Science can help to make the world a better place in the future.

Few scientists are happily married.

I would prefer to do an experiment on a topic than to read about it in science magazines.

In science experiments, I report unexpected results as well as expected ones.

I look forward to science lessons.

I would enjoy visiting a science museum at the weekend.

I would dislike becoming a scientist because it needs too much education.

Money used on scientific projects is wasted.

If you met a scientist, he would probably look like anyone else you might meet.

It is better to be told scientific facts than to find them out from experiments.

I dislike listening to other people’s opinions.

I would enjoy school more if there were no science lessons.

I dislike reading newspaper articles about science.

I would like to be a scientist when I leave school.
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For Teacher Use Only

S N I A E L C