Assessing the Scientific Literacy of Younger Students: Moving on from the Stereotypes of the Draw-A-Scientist Test

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Assessing the Scientific Literacy of Younger Students: Moving on from the Stereotypes of the Draw-A-Scientist-Test

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This study examined the extent to which the Draw-A-Scientist-Test (DAST) (Chambers, 1983) succeeds in assessing the scientific literacy of younger students. The DAST has been widely used and research based on it consistently reports the stereotypical views of scientists held by students. However, studies using variations on the DAST protocol, survey methods, and also interviews have reported increased levels of scientific literacy. The present study used semi-structured interviews with primary school students to examine their perceptions about scientists prior to administration of the DAST. The study found a disjunct between student drawings and student talk such that student talk reflected a more rounded view of the scientist than that afforded by the DAST. This study also reports the effect of varying the format of these interviews.

Introduction

Science educators emphasise the importance of scientific literacy (Goodrum, Hackling, & Rennie, 2001). Goodrum et al. state that scientific literacy involves not only an understanding of science concepts and facts but also an understanding of how scientists work and how knowledge is generated, replicated and validated. The preparation of future scientists is also a continuing goal of science education. Both these goals require school students to have an understanding of what is involved in working as a scientist. This study examines one current approach to measuring student perceptions about scientists and their work.

In the mid-sixties, Chambers (1983) developed the Draw-A-Scientist Test (DAST) to assess the scientific literacy of students, by examining student perceptions about scientists. The DAST requires students to draw a picture of a scientist on blank paper. The resulting drawing is analysed in terms of the presence of stereotypical images such as lab coat or eyeglasses. The DAST is quick and easy to administer and very useful for assessing younger students' perceptions as it does not rely on student verbal ability (Chambers, 1983; Schibeci & Sorensen, 1983).

Researchers have used the DAST very extensively, not only as a way of identifying student perceptions of scientists but also to measure the effectiveness of intervention programs designed to increase scientific literacy (Bodzin & Gehringer, 2001; Finson, Beaver, & Cramond, 1995; Flick, 1990; Huber & Burton, 1995; Mason, Kahle, &

Gardner, 1991). These studies have found that most students draw scientists as white males wearing lab coats and eyeglasses, with the number of stereotypic indicators increasing with student age. The low number of females drawn, especially by girls, is usually regarded as cause for concern (Kahle, 1993). Kahle argued, "…most students hold a masculine image of both science and scientists and that this image probably detracts from a girl's interest and self-confidence in doing science" (p. 23). In response to these studies, intervention programs have been implemented with the aim of addressing these stereotypes of scientists. Program outcomes, as evaluated by administering the DAST, have shown small decreases in the number of indicators in post-test drawings (Bodzin & Gehringer, 2001; Finson, Beaver, & Cramond, 1995; Flick, 1990; Huber & Burton, 1995; Mason, Kahle, & Gardner, 1991).

Maoldomhniagh and Mhaolain (1990) have criticised the extent to which the DAST measures scientific literacy. Maoldomhniagh and Mhaolain demonstrated that changes to the wording of instructions, such as asking students to 'draw a man or woman scientist', resulted in girls drawing significantly more female scientists than the control group. Symington and Spurling (1990) claimed that the instruction requires students to interpret what is required, and they may, therefore, decide that the task is to draw a person who is recognisable as a scientist. Thus the stereotypical image is drawn. To this end, students were asked to 'do a drawing which tells me what you know about scientists and their work', which gave a different view of children's perceptions. Barman (1999) also used modified instructions – 'draw a picture of a scientist doing science' – because it elicited more detailed drawings from young students. Barman also employed an interview protocol to allow students to explain their drawing, and to reduce misinterpretations. Matthews (1996) found that when children were asked to draw two scientists more female scientists were drawn. In this regard, Boylan, Hill, Wallace and Wheeler (1992) have raised concerns about the validity of the DAST in relation to the measurement of scientific literacy. Boylan, Hill, Wallace and Wheeler assert that the DAST elicits stereotypes because it indicates there is such a thing as a typical scientist.

Researchers have used survey methods to explore the scientific literacy of older students (Krajkovich & Smith, 1982; Song & Kim, 1999; Yager & Yager, 1985). Researchers interested in younger children's views have employed interview protocols such as The Interview-About-Instances procedure (Boylan, Hill, Wallace and Wheeler, 1992), which used a series of paired illustrations to provoke discussion. They reported that while students did hold stereotyped views about scientists, the interview format allowed them to "…display and discuss deeper conceptions of science and scientists" (p. 476).

In order to further assess the extent to which the DAST measures scientific literacy with younger students, Jackson (1992) followed-up the DAST with semi-structured interviews. Jackson administered the DAST with Year 1 and Year 2 students and then conducted an interview questioning students about stereotypical features of scientists reported in the literature. She found that the interview procedure "…drew on extensive knowledge about science and scientists that was untapped by the DAST" (Jackson, 1992, p.59).

Jackson's (1992) study interviewed young students after administering the DAST. A problem with this procedure is that one might expect the act of administering the test to have an effect on subsequent interview responses. Another aspect of Jackson's procedure that requires further examination is the use of group-based interviews. As with the prior presentation of the act of drawing, one might expect the presence of others to affect individual responses. For that reason, and in order to further test Jackson's finding, the current study has used both individual and group-based interview techniques to explore student perceptions about the scientist and science prior to administration of the DAST.

The current study partly replicated Jackson (1992) by indirectly comparing the quality of scientific literacy revealed in student drawings with that revealed in student talk prior to administration of the DAST. The current study also hypothesised that DAST-based estimates of scientific literacy would be influenced directly by variations in the type of student interview prior to administration of the DAST.

Method

Seventy-four primary school students, (39 male, 35 female) from Year 3 and 4 in one school, took part in a study to determine what knowledge and views of scientists young children possess, which are not assessed by the Draw-A-Scientist-Test. Students were first interviewed to determine what understanding they held about scientists and the work they do. Students were interviewed in two settings, 34 via individual semi-structured interviews, and 40 via two (year-level) semi-structured interviews. At the end of the interviews, students were asked to draw a scientist. Findings from the interviews and the DAST were analysed and compared with respect to a number of characteristics identified in prior research.

Results

Quantitative and qualitative techniques were employed to analyse the data collected. Scores obtained from a checklist were used to analyse drawings produced using the DAST-C. Text-analysis software, Leximancer, was used to identify the salient dimensions of student thinking about science and scientists, supplemented by manual text-analyses of emerging themes and patterns.

Analysis of DAST

The drawings were analysed using a scoring protocol developed for use with the DAST-C (Finson et al., 1995). This allowed for calculation of mean scores across the entire sample and also for comparison of scores between sub-groups. Percentages were also calculated for each indicator.

Descriptive statistics

The DAST-C used to analyse the drawings delivers a score out of 15 stereotypic indicators - the higher the score, the more stereotypic the image of the scientist. Table 1 shows the percentage of students per indicator. For convenience, scores in this study can be compared with those in the Barman (1999) study.

Table 1

Mean score by age and type of interview

TYPE OF INTERVIEW	DAST-C SCORES			
	N	Sum	Mean	Standard Deviation
Year 3 individual	11	56	5.09	1.58
Year 3 group	22	87	3.95	1.05
Year 4 individual	23	110	4.78	1.88
Year 4 group	18	72	4.00	1.24
Total	74	325	4.39	1.52

Table 1 shows the mean scores for the total sample, and also for each of the sub-groups. It is clear from this table that the Year 3 and Year 4 students who had been interviewed as individuals obtained higher scores on the DAST-C than those interviewed in the group situation.

Table 2

Mean scores across seven indicators (Chambers, 1983) for three studies plus current study

GRADE	AVERAGE NUMBER OF INDICATORS/ STUDENT			
Study	*Chambers, 1983*	*Schibeci & Sorensen, 1983*	*Sumrall, 1995*	*This study*
3	2.4	1.3	1.5	1.8
4	3.1	1.3	1.4	1.7

Table 2 illustrates mean scores per grade (Years 3 and 4) based on seven indicators (ref., Chambers, 1983), for three previous studies, and also this one. It is clear from Table 2 that scores in the current study lay in a similar range to those in previous studies.

Table 3

Percentage of stereotypical indicators for Barman (1999) and current study

DAST-C STEREOTYPIC INDICATOR	BARMAN (1999) YEARS 3–5, *N*=649	THIS STUDY YEARS 3–4, *N*=74
Caucasian only	80	100
Symbols of research	94	73
Male gender	73	72
Working indoors	88	69
Scientists wearing lab coat	41	47
Scientist wearing eyeglasses	28	38

As shown in Table 3, the majority of students, both in the Barman and the current study drew the scientist as Caucasian, with appropriate symbols of research, as male, and as working indoors. Interestingly fewer than 50% in either study depicted scientists as wearing a lab coat or eyeglasses.

In addition to the checklist, drawings were analysed in terms of the type of scientist represented. The categories developed by Matthews and Davies (1999) were used. Some patterns emerge from this analysis. Nearly half of the students drew a chemist, which was usually identified as someone working with materials, represented in the drawings by flasks and beakers. This aligns well with the analysis of the type of instrument drawn on the DAST-C. Of the 54 students who drew symbols of research, 39 drew some type of glassware, which is associated with chemistry.

However, these outcomes were influenced by interview conditions. Only one-third of individually interviewed students drew chemists, compared to 58% of the students interviewed in year-level groups. There was more variety in the types of scientists drawn by individually interviewed students, with similar proportions of chemists (32%), biologists (26%), and physicists/technicians (18%). Finally, of those interviewed individually, only one student drew a mad scientist, whereas five students in the group interviews drew a mad scientist.

Inferential statistics

SPSS MANOVA was used to conduct univariate analysis of variance, with the DAST-C scores as the dependent variable, and with gender (male, female), year level (year 3, year 4), and condition (individual, group) as independent variables. In this quasi-experimental design, interview condition predicted DAST-C significantly ($F(1,66)=7.704$, $p<.01$) such that participants who were interviewed individually obtained higher scores (that is, had more stereotypic indicators) than those interviewed in groups.

Analysis of interviews

Automated text analysis

Interview responses from all students were entered into Leximancer (Smith, 2002), a software package that identifies the significant dimensions of discourse by analysing the frequency of use of terms and the spatial proximity between those terms. The result of this analysis is displayed in a two-dimensional spatial representation.

Students generated a range of terms, including the term, scientist. This term was aligned with the vertical axis between Quadrants 1 and 2. The term, chemicals, then aligned with the horizontal axis between Quadrants 1 and 4. With these two terms thus aligned, the terms, stuff, and work approximately aligned with the vertical axis between Quadrants 3 and 4 (see Figure 1).

As shown in Figure 1, one way to interpret the clusters of terms based on these alignments is that students talked about the scientist either in terms of the scientific profession (science, real, scientists, cartoons: Quadrant 2) versus scientific outcomes (think, find, people, experiments: Quadrant 1). Here it is worth noting that the term, people, refers to people being helped by scientists.

Likewise, students spoke about stuff (referring to materials, objects) in terms of stereotypical indicators (lab, funny, wear, white: Quadrant 3) versus work in progress (animals, study: Quadrant 4). Here students use the term white to refer to scientists' clothing and refer to animals both in terms of studying them and helping them. Finally, with reference to the horizontal axis, students spoke about chemicals in relation to work in progress (animals, study: Quadrant 4) versus work outcomes (think, people, find, experiments: Quadrant 1). More generally, when the figure is considered in terms of the left half (Quadrants 2 & 3) versus the right half (Quadrants 1 & 4) of the display, student utterances can be summarised as concerned with either the professional image of the scientist (Quadrant 2 & 3) versus the work of the scientist (Quadrants 1 & 4).

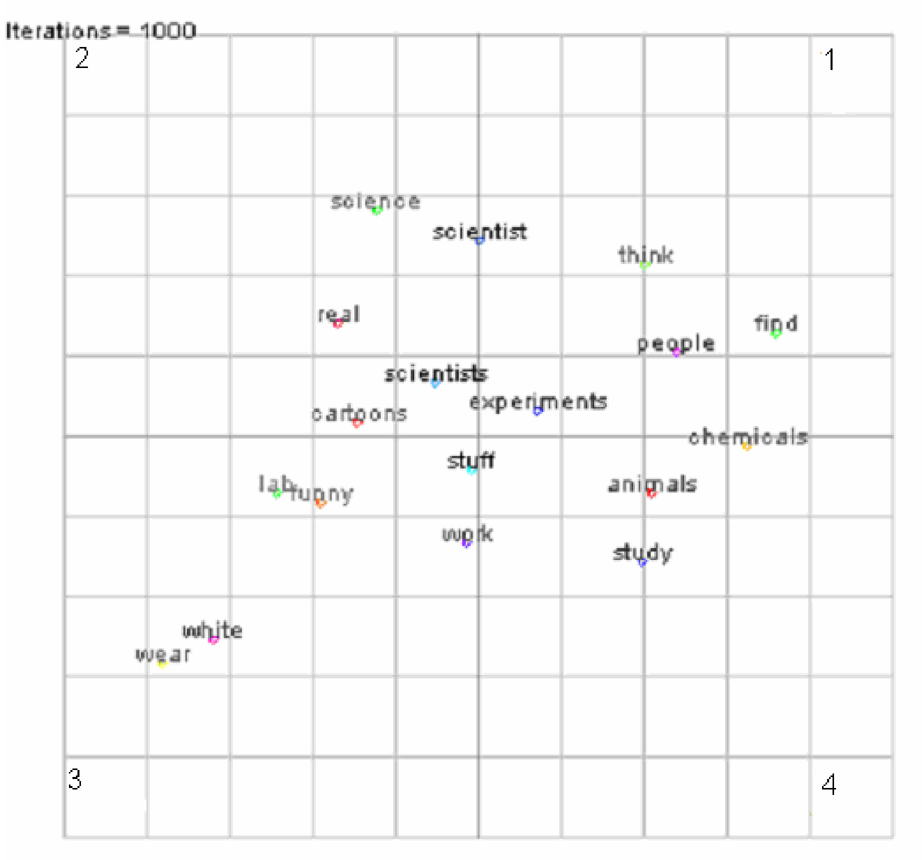

Figure 1.

Leximancer results for analysis of all interview data.

Manual frequency counts

Subsequent manual frequency counts of responses based on individual interviews further explored the two major themes identified above, that is, the professional image of the scientist, and the work of the scientist. The content of group interviews was not analysed directly because of difficulties in counting group-based responses, but was instead compared qualitatively with individual interviews.

The professional image of the scientist

Students were asked to recall scientists they had seen in the media and then compare these to real scientists. Most students were able to recall a scientist, drawing upon different media forms. They talked about scientists in movies, educational TV shows, television dramas and cartoons. In the individual interviews, 25% of students described the scientist in terms of distinctive white clothing. Another common descriptor used for media scientists was funny or humorous (22%). When comparing media scientists with real scientists, several students noted that the scientists in the media are often silly or funny, unlike real scientists. Students further distinguished between real scientists and those in the media on the basis of moral character. Real scientists were perceived as 'good' in comparison to 'evil' or 'mad' scientists. An example of this type of response comes from the Year Four group discussion: "Cartoon scientists can sometimes be evil scientists and some of them can be good scientists. But real scientists they're mostly all good."

Most students identified the white laboratory coat as indicative of what scientists look like. Often this was confused with capes, jackets, suits and white uniforms. Most students specified the clothing as white. Glasses and goggles were also common responses. Students often qualified statements about glasses or goggles by saying that they were worn by scientists to protect their eyes. Gloves were also discussed in terms of safety clothing.

When asked where scientists work, about two-thirds identified the laboratory or lab. Nearly 18% of students said that scientists work in offices or buildings. Only 15% said they did not know.

The work of the scientist

About two-thirds of students conceptualised the work of the scientist as studying or finding things out. An example of this type of response "discovers things and does lots of research" (Female, Year Four). Four students specifically referred to experimenting or testing things. Three students associated the work of scientists with inventing or making things. Often students gave more than one type of response, for example "They would work on experiments… because they always figure out things, try to explore the world" (Male, Year Four). These ideas about scientific work were also expressed in group interviews.

When asked what scientists study, one-third of students said that scientists study animals, and approximately one-quarter specifically stated the human body. Another 12% mentioned the study of medicine. 12% identified the study of plants. Astronomy was another frequent response (25% of students). 21% of the students associated scientific work with studying chemicals, also referred to by students as potions or liquids.

Discussion

The current study partly replicated Jackson (1992) by indirectly making comparisons of the quality of scientific literacy revealed in student drawings with that revealed in student talk. Descriptive analysis of the DAST responses generated similar findings to those reported in previous studies (see Tables 2 & 3, above) in that drawings produced by the current sample of primary school students contained a number of stereotypical qualities that could be interpreted as deficits in scientific literacy. In contrast, text analyses of interview data indicated that young students form more complex understandings of scientists and their work than was suggested by the DAST. Both the automated analysis and the follow-up frequency counts of categories of responses indicate these students to be aware of the difference between cartoonlike and real depictions of the scientist and the work of the scientist. In short, student talk has been shown to be indicative of a more rounded scientific literacy, consistent with results reported by Jackson (1992).

The current study also hypothesised that DAST-based estimates of scientific literacy would be influenced directly by variations in the type of student interview prior to administration of the DAST. The significant effect of interview condition in favour of students interviewed individually, suggests that the administration of the DAST-C in whole group settings might be a factor in the notably stereotypical outcomes reported using this test. It follows that future research into the scientific literacy of students could further explore the contexts provided by individual versus group-based administrations of the DAST.

Conclusion

This study has shown that the DAST only addressed one aspect of the scientific literacy of these primary age students. One way to interpret the pattern of differences observed for student drawings versus student talk is to postulate that students can express at least two levels of conceptualisation about scientists. The act of drawing captures the scientist's prototypical qualities but the opportunity to talk allows for a fuller and more accurate account of what it is to be a scientist.

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