Development and Field Test of the Modified Draw-a-Scientist Test and the Draw-a-Scientist Rubric

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Even long before children are able to verbalize which careers may be interesting to them, they collect and store ideas about scientists. For these reasons, asking children to draw a scientist has become an accepted method to provide a glimpse into how children represent and identify with those in the science fields. Years later, these representations may translate into students' career choices. Since 1995, children's illustrations of scientists have been assessed by the Draw-a-Scientist Checklist (DAST-C). The checklist was created from the common aspects or features found in illustrations from previous studies and were based initially on the scientists, broken down into "stereotypical" and "alternative" images shown in the drawings. The purpose of this article is to describe the development, field test, and reliability of the modified DAST Test and the DAST Rubric designed as an improvement of the DAST-C to provide a more appropriate method of assessing students' drawings of scientists. The combination of the modified DAST and the DAST Rubric brings more refinement as it enables clarities to emerge and subsequently increased detail to what one could ascertain from students about their mental images of scientists.

Asking students to "draw a scientist" is a popular practice for those wishing to probe the perceptions children hold of scientists and their work (Chambers, 1983; Finson, Beaver, & Cramond, 1995; Huber & Burton, 1995; Schibeci & Sorensen, 1983). Analyzing these images frequently involves labeling the representations of scientists as stereotypical, or alternative, based on the appearance of individuals in the drawing, not to mention objects in the drawing, including things such as lab coats, glasses, or beakers. Exactly how these images impact students' attitudes and learning remains uncertain. However, it is unlikely that students will pursue science careers if their perceptions of scientists do not fit their beliefs about themselves. Students' occupational preferences and career aspirations are strongly linked to their images of particular occupations (Gottfredson, 1981). There is reason to believe that young students may not consider careers in science because of the images of scientists they possess—negative images that may have been formed long before a career was ever considered (Fung, 2002).

The initial step toward understanding how students identify with scientists is to effectively analyze their drawings, which are the most common method of probing perceptions. This author suggests the information gathered from illustrations can be more than just a stereotypical or alternative label. Rather, the information can be multidimensional to help teachers and researchers develop more interventions, with the ultimate goal of positively influencing perceptions.

For some 50 years, researchers have documented that students typically portray scientists in drawings as males confined to a laboratory, surrounded by dangerous chemicals while conducting dubious experiments (Barman, 1997; Chambers, 1983; Fort & Varney, 1989; Mead & Metraux, 1957; Schibeci & Sorensen, 1983). The narrow impression of science held by students has, in part, inspired science reformers to create The National Science Education Standards (NSES) (National Research Council [NRC], 1996). Among other things, NSES advocates that science as a human endeavor be taught as early as elementary grades, "in order to provide a foundation for the development of sophisticated ideas related to the history and nature of science that will be developed in later years" (NRC, 1996, p. 141).

Perceptions of scientists held by students relate to their attitudes toward science and self-efficacy in science courses (Schibeci, 1989). Finson (2003) has linked students' perceptions of scientists and attitudes toward science to the selection of career choice. Exploring, reporting, and comprehending these perceptions are critical for educators because perceptions may affect students' attitudes about and interest in learning science, and may influence whether students pursue science in higher education (Fung, 2002).

The manner in which scientists are viewed by students needs to be fully understood. Entwisle and Greenberger (1972) suggested that perceptions of scientists are already formed by the end of students' elementary education. Chambers (1983) revealed that older elementary students included more indicators of stereotypical images in their illustrations than did five- to seven-year-old students, suggesting that by fourth and fifth grades, students already formed limited views of scientists. Children's drawings commonly reflected the cartoon-like view of scientists as individuals with crazy hair and thick glasses, working alone, and isolated from others because of their awkwardness in social settings (Barman, 1996, 1997; Chambers, 1983). It also is commonly accepted that students' illustrations of scientists are very similar across ages, settings, and grade levels when relying on drawings to make inferences about what students think regarding scientists and their work (Barman, 1997).

Assessing the Draw-a-Scientist (DAST) Historically

The stereotypical image of scientists gained worldwide status from a number of international studies that asked students to "draw a picture of a scientist" (Chambers, 1983; Chiang & Guo, 1996; Fung, 2002; Maoldomhnaigh & Hunt, 1988; Newton & Newton, 1992, 1998; She, 1998; Song, Pak, & Jang, 1992). The validity and reliability of the DAST was questionable, resulting in some skepticism and lower acceptance in the field of science education. It was not until a scoring mechanism called the DAST-Checklist (DAST-C) by Finson, Beaver, and Cramond in 1995 that researchers were able to focus on something else besides the initial "stereotypical image of the scientist" as expectations portrayed in students' drawings. The checklist was created from the common aspects or features found in illustrations from previous studies and were based initially on the scientists but not explicitly about their appearance, location, and activity. The DAST-C was an initial attempt to understand what students drew, the elements were derived from characteristics of drawings and interviews from children as reported in prior research. The checklist was designed to allow researchers to check off those items that had appeared most commonly (hence, more stereotypical) in prior research while notations were made for other items such as the magnifying glasses, etc. so that later analysis could account for those drawing components.

This attempt to catalog and categorize children's pictures of scientists knowingly had a limited function of what a child may be trying to convey concerning his or her ideas about scientists.

What Do Children's Pictures Tell Us?

Children's illustrations have long been accepted as their representation of how they view the world. Children's pictures are filled with information they are trying to convey. We have learned from past research (Barman, 1996, 1997; Chambers, 1983) that when prompted, children will draw a picture of a scientist, but they will also be able to verbalize a lot of information about the context of their illustration. This author found that by modifying the directions from merely "draw a scientist" to more lengthy expectations known as the modified DAST or mDAST (see later section), children were able to provide lots of details to represent how they were thinking about that particular scientist within a particular context. In the development and validation of the original DAST-C, interviews were included with students' drawings. However, the questions asked were more limited in their scope than those used for the mDAST. It is important to note that this improved method of analyzing students' perceptions of scientists requires a new protocol (mDAST) and assessment (DAST Rubric) to bring more refinement and increased detail to what one could ascertain from students about their mental images of scientists. This article will examine the development of the mDAST and DAST Rubric along with the initial field test of the two and whether or not it can be used by teachers reliably.

Research Question

This study explores the possibilities of assessing and analyzing students' perceptions of scientists with a multidimensional approach and was designed to answer the following question: Can a rubric specifically designed for the DAST Test be used reliably by teachers?

First, Refining the Protocol: The Development of the mDAST

After this author reviewed hundreds of sets of DAST Tests, it was evident students were providing much more information about perceptions of scientists than what was reflected in the previously established assessment one-dimensional assessment (DAST-C). For example, when students were asked to "draw a scientist," they often included much more than the appearance of the scientist. Oftentimes, it was evident most students were drawing scientists in particular places doing particular activities. It also was obvious students were able to illustrate the appearance (what scientists look similar to), location (where scientists work), and activity (what scientists do) of scientists in their drawings. In 2003, this researcher modified the DAST directions to explicitly include these three aspects—appearance, location, and activity. Several modifications to the "draw a scientist" directions were used as prompts, and it was determined that when students were specifically directed to draw all three aspects, they were capable of including all three in the context of their drawings.

As a result, a prompt was added directing students to include these three aspects and the mDAST (Farland, 2003) was developed. The directions were as follows: *Imagine that tomorrow you are going on a trip (anywhere) to visit a scientist in a place where the scientist is working right now. Draw the scientist busy with the work this scientist does. Add a caption, which tells what this scientist might be saying to you about the work you are watching the scientist do. Do not draw yourself or your teacher.*

Based on the DAST Test (DAST) developed by Chambers (1983), this test was also designed to capture students' images of scientist regardless of writing ability. The instructions for the original DAST were limited to "draw a scientist." The directions were expanded and improved to provide students with more detail. Students responded by incorporating aspects of appearance, location, and activity into their drawings, whereas the more general "draw a scientist" direction for the original DAST did not prejudice students and the drawings that resulted may have been more of a true reflection of what the students' images were. The researcher fully understands that the expanded version of the directions may cause some to question the specificity of the directions and can be regarded as leading the students into illustrations; however, this was not the researcher's intentions. Rather, the specific directions were intended to get those data and one would be less likely to get them through the use of the more general DAST direction.

A space was provided enabling students to illustrate their perceptions. This mDAST also was composed of a second page of four questions asking for specific information about the drawing in the event the illustration was unclear. The children were asked the following: I am a boy/girl; was the scientist you drew a man or woman?; was the scientist you drew working outdoors or indoors?; what was the scientist doing in your picture?

The mDAST was developed by the researcher and the directions were the result of many informal pilot studies in the researcher's own classroom. The researcher observed variations of these three categories while collecting hundreds of drawings. For instance, (1) who is doing science, (white male, female, minority) and the overall appearance of scientists (crazy, mad scientist, normal-looking), (2) what location the scientist is in (basement, laboratory, etc.), (3) what activity is being done (mixing chemicals, studying rocks, finding fossils), and (4) what tools are being used (from explosives to more commonly used tools such as magnifying glasses). A rubric was then created based on the variations collected, observed, and analyzed to create a comprehensive picture of the students' perceptions of scientists.

Second, Creating a New Assessment: The Development of the DAST Rubric

In assessing science content, today's classroom teachers have many options. One of these is the use of a rubric to assess children's knowledge. Rubrics can be designed to meet a variety of teachers' needs in an effort to analyze how children interpret the world in which they live. Using a rubric to analyze children's illustrations of scientists is appropriate because it allows for individual creativity as there is no right or wrong answer for illustrations as there often is with science content. Rather, it was found that after reviewing hundreds of students' illustrations of scientists, students tended to draw images that included the appearance, location, and activity of scientists that could be categorized in three different categories as sensationalized, traditional, or broader than traditional. Here is the first major difference between the DAST-C and the mDAST/DAST Rubric combination. The DAST-C simply limited scoring to whether or not a particular drawing element was present in the drawing. The refinements in the mDAST/DAST Rubric takes the assessment a couple steps further, actually on a continuum, as the drawings are labeled as "sensationalized," "traditional," "broader than traditional." A description of scoring ranges from 0–3 of the DAST Rubric in each of these three categories: the appearance of the scientists, the location of the scientists, and the activity of the scientists.

Appearance

Illustrations that score a "0" in appearance can be referred to as "cannot be categorized." These drawings may contain a stick figure, a historical figure, no scientist, or a teacher or student. Illustrations that score a "1" in appearance can be referred to as "sensationalized." These drawings contain a man or a woman who may resemble a monster or who has a clearly odd or comic book appearance. Illustrations that score a "2" in appearance can be referred to as "traditional." These drawings contain an ordinary-looking white male. Illustrations that score a "3" in appearance can be referred to as "broader than traditional." These drawings include a woman or a minority scientist.

Location

Illustrations that score a "0" in location can be referred to as "cannot be categorized." The scene of these drawings may be difficult to determine or that of a classroom. Illustrations that score a "1" in location can be referred to as "sensationalized." These drawings contain a location that resembles a basement, cave, or setting of secrecy, scariness, or horror, often with elaborate equipment not normally found in a laboratory. Illustrations that score a “2” in location can be referred to as “traditional.” The setting of these drawings is a traditional laboratory with a table and equipment (and possibly a computer) in a normal-looking room. Illustrations that score a “3” in location can be referred to as “broader than traditional.” These drawings include a scene that is not a basement laboratory and different from a traditional laboratory setting.

Activity

Illustrations that score a “0” for activity can be referred to as “difficult/unable to determine.” Illustrations that score a “1” in activity can be referred to as “sensationalized.” These drawings reveal an activity that may include scariness or horror, often with elaborate equipment not normally found in a typical laboratory. Drawings that include fire, explosives, or dangerous work also are included in this category. Illustrations that score a “2” in activity can be referred to as “naïve or traditional.” These drawings reveal an activity that the student believes may happen, but in truth, the activity is highly unlikely to occur. This category also includes drawings where the student writes, “This scientist is studying . . . or trying to . . . ” but does not show how this is being done. Illustrations that score a “3” in activity can be referred to as “broader than traditional.” These drawings portray realistic activities that reflect the work a scientist might actually do with the appropriate tools needed to perform these activities. A student may write, “This scientist is studying . . . or trying to . . . ” and shows how this is being done.

These three categories, appearance, location, and activity along with their scoring mechanism for sensationalized, traditional, and broader than traditional features are the nucleus of the DAST Rubric (Appendix).

Initial Field Test of the mDAST/DAST Rubric

The previously described DAST Rubric was developed by the researcher to specifically score the mDASTs (mDASTs). These tests were then divided and scored independently by two trained coders using the DAST Rubric. Each student drawing (or test) was given a raw score by each coder in the categories of appearance, location, and activity. The two scores were added together for a final raw score in each of the three categories. All student names were held in confidence.

While the DAST Rubric was designed to ensure consistency, it is still open to some interpretive differences inherent to the individual scoring the illustrations. In an effort to answer this question, “Can this rubric, which is specifically designed for the DAST Test, be used reliably by teachers?” Two sixth-grade teachers used the DAST Rubric to score two classes each and consistencies across scoring mechanisms were explored. Each drawing was coded twice, by two different coders for whom an inter-rater reliability of 90% was established during a two-hour training session.

The mDAST was field-tested during a research study in which classroom teachers administered the test. Each student was assigned a raw score from these drawings to give the student’s total score for each category on each test.

Training of Coders

Two classroom teachers were recruited as coders. Both did not have experience evaluating student illustrations. These coders were trained in scoring the drawings using the scheme outlined by the researcher in the Handbook for Scorers. This is a handbook developed by the researcher, designed to train individuals in coding the drawings by using multiple examples from past children’s work.

Coders participating in this research also received instruction about using the DAST Rubric during a one-day workshop. The coders were provided with sample drawings that represented each of the nine parts of the DAST Rubric, as well as drawings from previous pilot study exercises. An inter-rater reliability of 80% or better was sought. This percentage of accuracy was calculated based on the raw scores. The two coders scored the same set of drawings independently using the DAST Rubric. Neither scorer knew whether the drawings were from the control or treatment group. It should be noted that original DAST-C inter-rater reliability was calculated to be 94 to 98%.

Twenty practice drawings were scored until a consensus was reached on the raw score in each category: appearance, location, and activity and reported in Table 1. If the coders had any questions, they simply put a question mark near the category and it was later discussed by the coders and researcher until a consensus was reached.

Reliability/Validity of the DAST Rubric

Initial measures were taken to ensure the validity and reliability of the DAST Rubric. For internal validity, two coders were used to evaluate all drawings ($N = 156$) in a previous study by the author in 2003. In this study, two coders scored the same set of pictures independently using the DAST Rubric. In each case, scorers followed the directions and scored a complete set of pictures while assigning a raw score for each category: appearance, location, and activity. Each coder independently determined a score in

Table 1
Inter-Rater Reliability Data

	Inter-Rater Reliability (%)	Drawings Scored	Score Difference of One Point	Score Difference More Than One Point
Appearance	100	20	0	0
Location	95	19	1	0
Activity	90	18	2	0

Table 2
Inter-Rater Reliability Data Between Researcher and Teachers for Appearance

	Inter-Rater Reliability (%)	Number of Drawings Scored	Score Difference of One Point	Score Difference of More Than One Point
Teacher one	85	41	6	0
Teacher two	93	41	2	1
Total	89	82	8	1

each category and then the two scores were added together for one final score. A deviation of only one point between coders was acceptable. In the event the scores in any given category were more than one point apart, a third scorer, the researcher, scored the drawing independently, and this score was added to the closest score and the earlier score was discarded.

Participants

The study was conducted in a public school system in the Midwestern United States. The sample was composed of two teachers who willingly participated in this research study by scoring the pictures obtained from four sixth-grade classes (n = 82). Both teachers taught sixth grade and their teaching experience ranged from eight to 10 years. This researcher did not believe it was necessary to conduct classroom observations of the participating teachers as it was the first time these teachers had participated in scoring children's illustrations of scientists. They were recruited on a volunteer basis and received three science trade books for their participation.

Teacher Training

The purpose of the teacher training was to ensure each drawing was scored consistently by teachers with varying years of experience. Therefore, all the teachers were instructed in how to score the mDAST using the DAST Rubric in a one-hour workshop given by the researcher. The workshop included introduction of the researcher and research, goals of the intended study, teacher willingness to consent to participate, and administration of the mDAST and scoring of the DAST Rubric.

Results of the Analysis of Data

After each teacher was trained to administer the mDAST and score it with the DAST Rubric, the tests were administered in four of their classes within a two-week period. The drawings and scoring rubrics were given to the researcher, who then coded the drawings using the rubric without looking at the teacher's scores. The question guiding this research was the idea that one category may have been easier or more reliable than another. So in an attempt to understand the consistencies and patterns in scoring, each table reports the inter-rater reliability for the three components of the rubric. Table 2 reports the inter-rater reliability in scoring the appearance of the scientists in the illustrations. Table 3 reports the inter-rater reliability in scoring the location of the scientists in the illustrations. Table 4 reports the inter-rater reliability in scoring the activity of the scientists in the illustrations.

The experience of having these two teachers score their classes with the DAST Rubric demonstrated considerably reliable results. The inter-rater reliability for the appearance category was a combined 89%, the location category was a combined 94%, and the activity category was a combined 88%. It appears the scoring of the location category is the most reliable (94%) when compared with the

Table 3
Inter-Rater Reliability Data Between Researcher and Teachers for Location

	Inter-Rater Reliability (%)	Number of Drawings Scored	Score Difference of One Point	Score Difference of More Than One Point
Teacher one	95	41	0	1
Teacher two	90	41	3	1
Total	94	82	3	2

Table 4
Inter-Rater Reliability Data Between Researcher and Teachers for Activity

	Inter-Rater Reliability (%)	Number of Drawings Scored	Score Difference of One Point	Score Difference of More Than One Point
Teacher one	93	41	3	0
Teacher two	83	41	5	2
Total	88	82	8	2

other two categories. It would make sense that this category would be the clearest and/or easiest to score because it uses the information about scientists' location to determine the score. There is little discussion or room for different interpretation if a scientist is portrayed in a basement, in a typical lab, or outdoors. The activity and appearance categories would be the least reliable because they would be the categories open to different interpretations. For example, it is easy to categorize illustrations that include "sensationalized" activities such as spying, killing, or stealing. But it is more difficult to discern activities that the student believes may happen but in truth is highly unlikely to occur. The difference between a "traditional" and "broader than traditional" label in the activity category is that the child neglected to clearly demonstrate how an activity is being done. Rather, students write "this scientist is studying . . . or trying to . . . " and does not show how this is being done or identify the accurate tools needed to perform these activities. In order to be labeled "broader than traditional," these drawings portray realistic activities that reflect the work a scientist might actually do with the appropriate tools needed to perform these activities. The discrepancy between these two categories appears to be where the teachers had the most difficulty.

In the appearance category, sometimes it is difficult to discern whether or not a child makes a "sensationalized" representation of a scientist. For example, a child may draw a disproportional figure because of his or her drawing abilities not because that is what he or she is trying to represent, and the scorer may have a difficult time deciding if it is in fact "sensationalized" or reflective of that particular child's artistic abilities.

In this study, the students were asked to use their artistic ability to portray their images of scientists. The students' ability to illustrate what they actually perceive is a limitation and may cause confusion to some scorers. A weakness of the study remains in scoring the drawings. Two or more scorers may assess as illustration and get two different interpretations. While the DAST Rubric was designed with this limitation in mind, it can never be a totally objective measure of students' drawings as factors involving who scores the drawings will always be present. On that note, this study established with confidence that two different teachers scored the illustrations reliably when compared with the researcher.

Discussion

Interpretation of the results of the DAST was previously limited by the narrow range of data it provided. In order for educators to accurately evaluate and analyze perceptions of scientists and their work to drive future instruction, they must have a multidimensional in-depth tool to analyze how children may be thinking about scientists. Helping students develop positive perceptions of scientists can only be preceded by a comprehensive assessment of the perceptions they harbor. In the classroom, the mDAST/DAST Rubric is useful in assessing students' initial perceptions about scientists and science, thereby helping teachers to understand and broaden those perceptions. The mDAST/DAST Rubric allows teachers to see similarities and differences in whole class perceptions of scientists, enabling teachers to target instruction as necessary.

The major difference between the DAST-C and the modified form was that the DAST-C did not break down the analysis into three distinct subscales (appearance, location, activity) but broke them down into "stereotypical" and "alternative" images shown in the drawings. The three subscale concepts in the mDAST were embedded within the original DAST-C, but the mDAST/DAST Rubric made it easer to expose those specifics. Both utilize the assignment of scores and counting points, and both look at qualities of the drawings (descriptive aspects, etc.). However, the mDAST/DAST Rubric is better suited to analyze children's perceptions of scientists because it separates the child's work into three subdimensions or scales (appearance, location, and activity) than the DAST-C did, and that gives it some added utility that the DAST-C did not have.

Because this assessment is easy to administer and score, it can be used in a multidimensional manner that was more difficult with the previous assessment, the DAST-C. The DAST Rubric is superior because it is able to extract more information from drawings and more effectively measure changes in students' perceptions about scientists and science. This study demonstrated that much more information could be gleaned from the standard DAST than had previously been available, but this required the development of a modified protocol, and a rubric to standardize data collection in a variety of subdomains (appearance, location, and activity) of the scientist. The separation of the categories of appearance, location, and activity allows children's perceptions to be viewed in three different lenses, creating a kaleidoscope of children's perceptions versus a checklist. And the DAST Rubric, when administered along with the mDAST and evaluated by trained individuals, is a reliable tool in identifying perceptions, which are helpful in nurturing interest in scientists and science among students.

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Appendix A
Description of Scoring Categories in the DAST Rubric

Appearance

Illustrations which score a "1" in APPEARANCE can be referred to as "sensationalized." These drawings contain a man or a woman who may resemble a monster or who has clearly odd, or comic book-like APPEARANCE. Illustrations which score a "2" in APPEARANCE can be referred to as "traditional." These drawings contain a standard looking white male. Illustrations which score a "3" in APPEARANCE can be referred to as "broader than traditional." These drawings include a minority or woman scientist. Illustrations which score a "0" in APPEARANCE can be referred to as "can't be categorized." These drawings may contain a stick figure, a historical figure, or no scientist or a teacher/student.

Location

Illustrations which score a "1" in LOCATION can be referred to as "sensationalized." These drawings contain a LOCATION that resembles a basement, cave, or setting of secrecy, scariness or horror, often with elaborate equipment not normally found in a laboratory. Illustrations which score a "2" in LOCATION can be referred to as "traditional." The setting of this drawing is a traditional laboratory with a table and equipment (may include a computer) in a normal-looking room. Illustrations which score a "3" in LOCATION can be referred to as "broader than traditional." These drawings include a scene that is not a basement laboratory and different from a traditional laboratory setting. Illustrations which score a "0" in LOCATION can be referred to "cannot be categorized." The scene of this drawing may be difficult to determine or that of a classroom.

Activity

Illustrations which score a "1" in ACTIVITY can be referred to as "sensationalized." These drawings reveal an ACTIVITY that may include scariness or horror, often with elaborate equipment not normally found in a laboratory. Drawings which include fire, explosives, or dangerous work are also included in this category. Illustrations which score a "2" in ACTIVITY can be referred to as "naïve or traditional." These drawings reveal an ACTIVITY that the student believes may happen, but in truth, the ACTIVITY is highly unlikely to occur. This category also includes drawings where the student writes, "this scientist is studying . . . or trying to . . . ," but does not show how this is being done. Illustrations which score a "3" in ACTIVITY can be referred to as "Broader than Traditional." These drawings portray realistic activities that reflect the work a scientist might actually do with the appropriate tools needed to perform these activities. A student may write, "this scientist is studying . . . or trying to . . . ," and shows how this is being done. Illustrations which score a "0" for ACTIVITY can be referred to as "difficult/unable to determine."