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How Does Culture Shape Students' Perceptions of Scientists? Cross-National Comparative Study of American and Chinese Elementary Students

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Abstract

For decades, researchers have been convinced that one stereotypic image of scientists existed among children worldwide (Chambers, 1983; Chiang & Guo, 1996; Fung, 2002; Maoldomhnaigh & Hunt, 1988; Newton & Newton, 1992, 1998; She, 1998; Song, Pak, & Jang, 1992). This study, however, moves beyond that stereotypic image and examines students' perceptions of scientists. The purpose of this study is to illustrate that students are influenced not only by the personal images they hold of scientists, but also by cultural impressions and the style of the science courses they experience in school. By combining a contemporary perspective and a creative method of analyzing student perceptions, a theoretical understanding of how students interpret scientists and their work was developed. Elementary school children (N = 1,350) in the United States and China were enrolled in this study, and drawing exercises were utilized to provide new evidence and a fresh perspective regarding the way students perceive scientists. Based on the findings of this research, more American students included the traditional image of a science laboratory with chemicals in their pictorial depictions of scientists, while Chinese students included robots in their drawings. While students in both countries demonstrated misconceptions about scientists, this study identifies those misconceptions as significantly different, yet inherently related, to students' individual cultures, contrary to previous studies. This study also demonstrates that a child's environment can be influenced by their existing culture, and thus learning, or perceiving the role of scientists, can be directly influenced since each classroom is a culture of its own. Finally, this study demonstrates that a child's sense of who can be a scientist, where scientists work, and what scientists do is influenced by cultural experiences. Today, with fewer students pursuing science careers, these findings are especially noteworthy.

Introduction

A child's development and capacity for learning is related directly to the symbolism and the culture of the country in which the child lives. Bruner (1996) labeled this effect *culturalism*. Education is just a small part of how cultures invest in future generations, yet a vital part. It is within this cultural context that schools become more than curriculum and textbooks, and more about the broader context of how they plan to educate children. The focus of this study is to examine how cultures influence young students and how cultures help students to construct images of the world around them—based on how students pictorially illustrate their perceptions of scientists.

This researcher contends that students undergo a specific process when developing perceptions of scientists and that process is intimately related to one's culture. It is a process that begins with children viewing scientists with positive or negative associations from within their culture. Students typically look to culture and people within their immediate environment to help reinforce or redefine their perceptions while synthesizing their own ideas. As children mature, they begin constructing personal perceptions of scientists, which are unlikely to change until they have personal contact with a scientist or experience a situation that causes a change in perceptions. For these reasons, students in different cultures are best examined in a cross-national comparative study in order to isolate which cultural factors help shape perceptions of scientists and which do not.

While educational researchers often discuss the significance of one's culture in relation to children and education, culture has never previously been linked in terms of how children perceive scientists. By understanding how cultures influence young students' perceptions about scientists, educators will be better able to create classrooms and curriculum that will help inspire student interest in the sciences and scientists at a time when those interests are waning in the United States. If we can examine what factors contribute to students' perceptions, then perhaps we in the United States can create cultures that influence students' perceptions of scientists in a positive way. In an effort to conduct a thorough and comprehensive evaluation of how students perceive scientists and the impact of culture on those perceptions, children from a community in the United States and from a community in China were selected for this study.

Students and Their Ideas About Scientists

For many years, versions of the Draw-A-Scientist Test (DAST) have been used as a tool to assess students' attitudes and perceptions about scientists (Barman, 1996, 1997; Chambers, 1983; Finson, Beaver, & Crammond, 1995; Mason, Kahle, & Gardener, 1991). Students taking the DAST are asked to draw a scientist. The resulting drawings typically reflect a cartoon-like view of the scientist—a person with crazy hair and thick glasses, working alone and isolated from others because of social awkwardness (Barman, 1996, 1997; Chambers, 1983). It is notable that illustrations of this sort are very similar across ages, settings, and grade levels—at least when one single drawing of a scientist at work is analyzed (Barman, 1997).

This stereotypic image of the scientist gained worldwide status from a number of international studies (Chambers, 1983; Chiang & Guo, 1996; Fung, 2002; Maoldomhnaigh & Hunt, 1988; Newton & Newton, 1992, 1998; She, 1998; Song, Pak, & Jang, 1992). Newton and Newton (1992) brought attention to the commonality of scientist pictures by observing children across cultures and the perceptions those children developed at early ages. Through the use of the DAST and other DAST-like protocols, children in a variety of cultures appear to perceive scientists with stereotypic commonalities, such as a lab coat, glasses, and chemicals, in the traditional manner. There also appeared to be similarities in the number of stereotypic indicators included in the drawings as students grew older as well as a predominant perception of scientists as male (Barman, 1997; Fung, 2002). Thus, with previous scoring mechanisms, children from different cultures appeared to be very similar both in their portrayal of scientists and the way these perceptions changed as children progressed through school, regardless of their geographic location.

In the past, teachers and researchers alike have relied on single drawings by students to try to understand what students think about scientists and their work. This was the case in the previously mentioned studies comparing American and Chinese students (Chiang & Guo, 1996; She, 1995, 1998). The idea that a single drawing may not reflect the wide range of views that a student possesses was missing from these previous studies. These previous studies also did not consider that the standard interpretive scoring mechanism may fail to provide as much rich information as that from a more intense examination of student drawings (Farland & McComas, 2006).

Changing Trends in Measuring Students' Ideas About Scientists

By having students create multiple drawings of scientists, it is reasonable to assume that those students have a sufficient opportunity to represent their ideas about scientists. For example, if they hold a robust view of the work of science and the true nature of who can be a scientist, it will be evident across multiple pictures. On the other hand, if a student draws the same image three times, there is good reason to believe it is the student's only view (Farland & McComas, 2006). The incorporation of multiple drawings and a new scoring mechanism led these researchers to create the Enhanced Draw-A-Scientist Test (E-DAST).

Elementary school children were selected in the United States and China as an initial step in providing evidence and a fresh perspective regarding the way culture influences students' perceptions about scientists. A brief discussion of the differences between the educational systems within these two cultures follows.

Comparing the Educational Systems of the Two Cultures

The most striking difference between these two countries, at least to the outside observer, is the vast difference in population. China has 1.5 billion people compared to 300 million in the United States, making China's educational system the world's largest with 214 million primary and secondary students—more than four times the number of students in the United States (Asia Society, 2006). In elementary schools in China, it is not uncommon to have 1,000 students enrolled in one school, while elementary schools in the United States typically house between 200 and 500 children. It also is not uncommon to find 60 or more students in a single Chinese elementary classroom.

Like the United States and other nations, China relies on national standards and curriculum to guide textbook content, teacher training, and professional development. However, China's national curriculum is far more standardized and more rigorously enforced than standards in the United States. In China, the district government chooses the curriculum and implements it. As a result, an observer visiting any number of elementary schools on any given day in a specific Chinese district would notice teachers teaching the very same science lesson in the very same way. In the United States, state and national standards serve more as a set of principles to help guide curriculum. As a result, teachers in the United States are more likely to design lessons that reflect the strengths of their teaching styles and students' needs and interests.

Both the United States and China have undergone major educational reform. In the United States, science education reform has been consistent for a number of years and has been unified around the concept of inquiry and the processes associated with it. When the National Research Council (NRC) recommended efforts to revamp science curriculum, it stressed the need for inquiry-based teaching methods, professional development, and teacher education. Inquiry-based approaches have been well-researched and are beneficial at promoting greater achievement among diverse groups of students, which has prompted the use of inquiry-based methods in teaching science. Along with these efforts, there has been a continual effort to shift teachers' beliefs toward inquiry-based methods, especially when teaching science (Smolleck, Zembal-Saul, & Yoder, 2006). There seem to be similar educational challenges in China (Zhang, Krajcik, Sutherland, Wang, Wu, & Qian, 2005), but less is known about the circumstances faced by Chinese elementary teachers in terms of inquiry-based teaching approaches.

Understanding the similarities and differences in educational systems, not to mention cultures, and their impact on children also may help in developing positive perceptions that motivate students to consider careers in science. For the purposes of this study, science careers are defined as those occupations that utilize knowledge of engineering and the natural and physical sciences. They include engineer; research scientist; statistician; conservationist/forester; and all persons with majors in the biological sciences, physical science, or engineering. Science-practitioner occupations, which include physician, dentist, veterinarian, pharmacist, and optometrist, fall within "science fields" in this study.

Research Questions

The following three questions were asked:

1. Are there cultural differences in the way Chinese and American elementary students portray the appearance of scientists?
2. What are the differences in the way Chinese and American elementary students portray the places where scientists work?
3. What are the differences in the way Chinese and American elementary students portray the activities of scientists?

Participants

This study began in the United States. Study participants from the U.S. consisted of 225 4th- and 5th-grade students—113 male and 112 female students from a public school system located in the Midwest. Participants from China consisted of 225 4th- and 5th-grade students—118 male and 107 female students from public schools in Southern China. In both cases, American and Chinese students were randomly selected and invited to participate, provided they were willing to cooperate in study activities and had parental permission.

Method

Once parents consented in writing and children consented verbally, the researcher administered the E-DAST. American students were given the test first, followed by the Chinese students. Students from both countries were given a piece of legal-sized white paper and asked to fold it into three equal boxes. They were instructed to place the paper with only one box showing and then were read the directions (Appendix A) two times.

Students then were instructed to draw a picture of a scientist in the one box in front of them. Both American and Chinese classes were monitored by the researcher to ensure students drew in only one box and worked independently. Upon completing the exercise, students were instructed to unfold the paper and draw two more scientists using the directions previously described. It is important to note that students did not know in advance that they would be asked to make multiple drawings.

This study employed a mixed-method approach, and all student names were held in confidence. The DAST Rubric (Farland, 2003) was used as a deductive qualitative tool to score the E-DAST. These drawings were then divided and scored independently by two trained coders and each student drawing was given a raw score by each coder in the categories of Appearance, Location, and Activity. The quantitative portion, including the analysis of raw scores in each of the three categories, is addressed in a separate paper. This paper focuses on themes relative to the three aspects of the DAST Rubric.

Data Analysis

While the DAST Rubric was designed to ensure consistency, it is still open to some interpretive differences inherent to the individual scoring of the illustrations. Hence, 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 researcher and one trained assistant coded and scored 450 sets (225 from U.S. and 225 from China) of three drawings using the DAST Rubric in three specific categories: Appearance, Location, and Activity. The DAST Rubric assigns a score (from 0 to 3) for these three separate categories within each picture. The first category is Appearance or "what scientists look like"; the second category is Location or "where scientists work"; and the third category is Activity or "what scientists do." Details about the scoring appear in Appendix B.

Overall, a total of 1,350 single pictures of scientists were analyzed. Half of those were drawn by 4th and 5th graders in the United States, and the other half were drawn by 4th and 5th graders in China. These were then scored and coded. At the conclusion of scoring, each of the three drawings was labeled *Stereotypical*, *Traditional*, or *Broader than Traditional* and was assigned three scores for Appearance, Location, and Activity. Drawing #1 was compared with Drawing #2 and Drawing #2 was compared with Drawing #3 to look for any patterns in the series of drawings between the two groups. Patterns that emerged based on the design of the DAST Rubric will be discussed in an effort to answer each research question.

Results

1. Are there cultural differences in the way Chinese and American elementary students portray the appearance of scientists?

The researcher first wanted to examine if there were any differences in the gender drawn by each population. There were 225 sets of drawings x 3 drawings each = 675 drawings total.

Female Results

For the American sample, 112 female participants drew three drawings each for a total of 336 drawings. Female participants drew female scientists 189 times for a total of 56% of the time, and they drew male scientists 42% of the time. For the Chinese sample, 107 participants drew female scientists 123 times for a total of

38% of the time and drew male scientists 198 times for a total of 62% of the time. American female participants drew one female and one male scientist in the same drawing seven times for a total of 2% of the time. The American male participants drew one female and one male scientist in the same drawing four times for a total of 1% of the time. Neither the Chinese females nor males drew a team of scientists in their pictures. Table 1 summarizes these findings.

Table 1. Gender Distribution of Scientists

	American Females (N = 112)	Chinese Females (N = 107)	American Males (N = 113)	Chinese Males (N = 118)
Female scientists	56%	38%	14%	6%
Male scientists	42%	62%	85%	94%
Male & female scientists	2%	0%	1%	0%

Male Participants

There were 113 American males who completed three drawings each for a total of 339 drawings and 118 Chinese males who completed three drawings each for a total of 354 drawings. The American male students drew male scientists 287 times for a total of 85% of the time and female scientists 14% of the time. The Chinese male students drew male scientists 331 times for a total of 94% of the time and drew female scientists 6% of the time.

When comparing the genders of study participants, it appears that a higher number of American students drew female scientists (35% of the time) when collectively adding the scores from both boys and girls, compared to 22% of Chinese students. The translation in Picture #1 reads “Female Scientists are rare . . .,” which further reinforces the low percentage of females drawn by the Chinese students. The overall gender results appear to be consistent with gender distribution from previous research (Barman, 1997; Chambers, 1983). Only American students, though relatively a small percentage (3% of the time), depicted teams of scientists.

Picture #1

Recall that this research focused on answering the question, "Are there cultural differences in the way Chinese and American elementary students portray the appearance of scientists?" Farland (2003) established that children's ideas about what scientists look like fall into one of three settings: (1) *Stereotypical,* a drawing that contains a man or a woman who may resemble a monster or who has a clearly odd or comic book-like appearance; (2) *Traditional,* a drawing that includes a scientist as an ordinary-looking Caucasian male; and (3) *Broader than Traditional*, a drawing that includes a minority or a woman scientist or a team of scientists (see Table 2). If the person in the drawing was difficult to determine or was a stick figure; a historical figure; or was not a scientist, teacher, or student, it was removed from the analysis.

Table 2. Representations of Scientists Across Samples

	Stereotypical	Traditional	Broader than Traditional
American participants	27%	37%	36%
Chinese participants	39%	49%	19%

Table 2 illustrates that more Chinese students held *Stereotypical* images of scientists when comparing across entire populations. A greater proportion of Chinese students held *Traditional* images of scientists when compared to the American students. The biggest difference among the populations was in the *Broader than Traditional* image of scientists, with American students holding the broader or less stereotypical images.

2. What are the differences in the way Chinese and American elementary students portray the places where scientists work?

Farland (2003) established that children's ideas about where scientists work fall into one of three settings: (1) *Stereotypical*, a setting which resembles a basement, cave, or scenes of secrecy, scariness, or horror, often with elaborate equipment not normally found in a real laboratory; (2) *Traditional*, a traditional laboratory with a table and equipment, and possibly a computer, in a normal-looking room; and (3) *Broader than Traditional,* a setting or scene other than a basement laboratory and different from a traditional laboratory setting that might include the outdoors, the ocean, or a volcano. If the scene or setting of the drawing was difficult to determine or was a classroom, it was removed from the analysis.

The purpose of asking this question was two-fold. First, would students from each group draw the same locations in an even distribution and, second, were there cultural influences or differences in the pictures from the two groups.

When comparing the two sample groups, it was discovered that a higher percentage of Chinese students (32%) drew their scientists in places that resembled basements, caves, or settings of secrecy, scariness, or horror, often with elaborate equipment not normally found in a real laboratory compared to American students (9%). Fifty-nine percent of American students drew their scientists in a traditional laboratory with a table and equipment, and possibly a computer, in a normal-looking room compared to 31% of Chinese students. When comparing the two populations, a higher number of American students (29%) included a scene or setting that was not a basement laboratory and was different from a traditional laboratory setting, compared to 12% of Chinese students.

When examining these pictures closely, it was found that Chinese students included themes in their settings or locations that appear to be related or unique to their culture. Many Chinese students included a bed or "resting place" in their pictures as seen by Picture #2 below. In the picture, the scientist appears to be an older Caucasian male working indoors and creating a robot. In China, it is very common to nap mid-day in order to improve one's creativity. Thus, the bed featured in the illustration is a very real part of the Chinese culture. It is important to note that not one bed or resting place was included in any of the 675 pictures drawn by American students.

Picture #2

Comparing settings among the two groups, another feature related to cultures was uncovered involving basements. Basements were often portrayed in pictures drawn by American students, while not one basement was represented in the 675 pictures drawn by Chinese students. The most reasonable and logical explanation is that Chinese students in this study lived in high-rise apartments and did not have personal experiences with basements. Picture #3 shows an American student's portrayal of a scientist in a basement. This setting was common among previous studies (Barman, 1997).

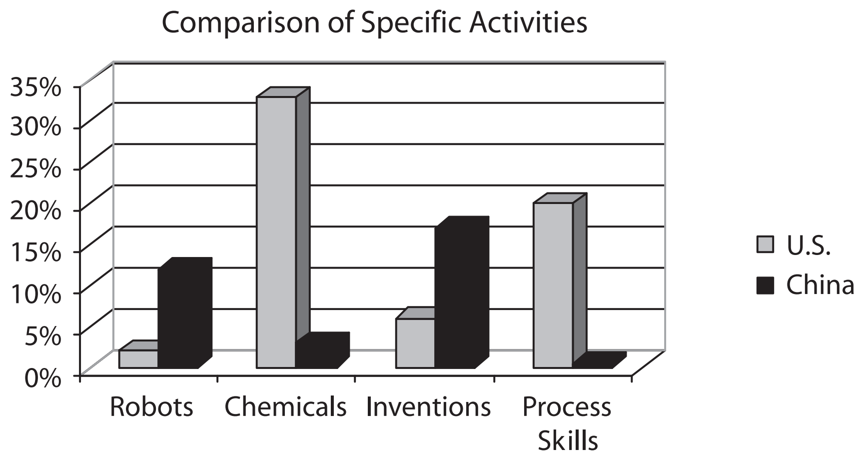
Picture #3

3. What are the differences in the way Chinese and American elementary students portray the activities of scientists?

Farland (2003) established that children's ideas about the work scientists do fall into one of three categories: (1) *Stereotypical*, a drawing may reveal an activity that includes work associated with scariness or horror, often with elaborate equipment not normally found in a real laboratory. Drawings with fire, explosives, or dangerous work are also included in this category; (2) *Traditional*, a drawing that reveals an activity the student believes may happen, but, in truth, the activity is highly unlikely to occur. This category also includes drawings in which the student writes, "[T]his scientist is studying . . . or trying to . . .," but does not show how this is being done; and (3) *Broader than Traditional*, a drawing may portray realistic activities that reflect the work a scientist might actually do with the appropriate tools needed to perform these activities. A student might write, "[T]his scientist is studying . . . or trying to . . ." and shows how this is being done. It is worth noting that if the activity of drawing was difficult to determine or not associated with science, it was removed from the analysis.

Among the 1,350 drawings generated in this study, many different scientist activities were presented. However, four major themes were prevalent as seen in Graph 1.

Graph 1. Distribution of Students' Perceptions of the Activities of Scientists



Many more Chinese students identified robots and inventions (a combined 29% of the drawings) as activities done by scientists (see Picture #3). American students, on the other hand, tended to draw more pictures with chemicals (Picture #4) or the process skills associated with science (i.e., observing, measuring, predicting, etc.) (Picture #5) with the appropriate tools. Also, Chinese students tended to focus on the making of robots (Picture #6) and the creation of monsters instead of the use of chemicals. This stereotype is present in the Chinese culture and serves as an influence about how scientists are perceived. This researcher would have been hard pressed to find a drawing from a Chinese student that included beakers and chemicals. Likewise, few American students participating in this study included robots in their pictures.

Picture #4

Picture #5

Picture #6

Discussion

Using multidimensional aspects of E-DAST, previously established similarities in the ways in which children perceive scientists can be explored in greater depth. This new analysis of students' perceptions modifies earlier assumptions that all students, American or Chinese, hold similar stereotypic perceptions of scientists that are not affected by culture. This analysis demonstrates a clearer understanding regarding the impact of cultures on American and Chinese students, and the resulting perceptions about scientists. Contrary to earlier research, this study found that a cultural influence is present among students that contributes to their understanding of who does science, where science is done, and what scientists do. This modern view, as opposed to the stereotypic notion developed decades ago, is important when looking at how perceptions can be influenced in the classroom.

Why did American children in this study tend to associate chemicals and beakers with the processes of science? Why did Chinese students associate robots and inventions with scientific activities? Why did only American students illustrate teams of scientists? Why were the majority of female scientists drawn by American students? What parts of the students' individual culture contribute to these perceptions?

Previously, DAST and tests like it have not been used to measure students' perceptions about scientists and the nature of science, yet little is understood about how these perceptions form. By examining these pictorial representations with a multidimensional rubric, distinctions can be established and researchers can begin questioning why and how children from different cultures construct their ideas about scientists and science so differently. For instance, can differences in American and Chinese educational systems contribute to the way children experience science in the classroom?

American students included process skills in their drawings of scientists, which should come as no surprise. In the United States, educators have placed more emphasis on the process skills of science in classroom science studies as a result of science reform. The resulting inquiry-based teaching methods, which are stressed in the United States, are relatively new in China.

In the United States, science education reform has been consistent for a number of years and is unified around the concept of inquiry and the processes associated with it. When the NRC recommended efforts for revamping science curriculum, a major component included inquiry-based teaching methods and teacher education. Are these inquiry-based approaches to how science is taught evident when probing students' perceptions of scientists? Finson, Pederson, and Thomas (2006) concur with the idea that a teacher's teaching style has some impact on student learning and the perceptions students develop about science and scientists. In a small study with nine teachers, a positive correlation was found between children's illustrations and teacher's teaching styles.

The data collected in the large-scale study presented here echoes these findings. Many American students enrolled in this study portrayed scientists doing some of the very same process skills these children use during science classes in school—measuring, predicting, and analyzing. That being the case, science education in the classroom may contribute more to students' perceptions of scientists than previously determined.

What would cause more American students to think that teams of scientists work together or that women can be scientists just as easily as men? Have schools and society carried these messages to both young boys and girls in the U.S., but not in China?

The Cultural Influence of the Stereotypical Scientist

Pertinent themes from each group's representation of the stereotypical scientist emerged from this study. For example, there was a significant difference in the stereotypic portrayal of scientists between American and Chinese students. American students tended to portray a male figure surrounded by beakers and chemicals such as in Picture #5. Meanwhile, Chinese students tended to portray a scientist as a male figure surrounded by tools and robot parts (see Picture #7).

Picture #7

Furthermore, by incorporating features like basements and beds in their drawings, students represented the impact of culture on their perceptions of scientists. Next, the connection between studying students' cultures and their relationship to how they perceive scientists will be established.

Cultural Connections to Classroom Implications

Students are influenced not only by the personal images they hold of scientists, but by their culture and the content of the science courses they experience in schools. A child's sense of who can be a scientist, where scientists work, and what scientists do is closely related to their cultural experiences. As a result, learning about, or perceiving, the role of scientists can be directly influenced by the classroom since each classroom is a culture of its own.

This study examined the large-scale idea of culture between countries, but what if teachers could focus on the small-scale version of cultures within their own control? For example, what kind of a culture would working side by side with scientists create for young learners? Previous successful interventions suggest that culture can contribute to students' conceptual development of scientists through the use of visiting scientist programs (Flick, 1990) or historical, nonfiction trade books (Farland, 2003). Both efforts have generated promising results in helping students debunk or challenge inaccurate perceptions of what scientists look like and do.

Why is it important for teachers to be aware of the role of culture in the classroom? If science educators can assume that humans construct their own knowledge, we can agree that knowledge takes place within the context of social interaction and culture. In learning about scientists, students may have to give up, replace, or exchange their previous ideas for a new understanding about the work scientists do. Traditionally, the overwhelming culture of science education has centered on mastering a designated body of knowledge. Consequently, students have obtained a narrow and somewhat erroneous impression of science and scientists. Today, teachers are challenged to provide a culture that fosters and broadens students' understanding of who does science, where scientists work, and what scientists do.

Making students aware of real scientists can be a huge benefit in exciting students about science and the possibility of pursuing careers in science—careers that are experiencing a dramatic loss of interest in the United States today. These messages must be incorporated with traditional science content in the classroom and must be systematically and deliberately taught to young children (Roach & Wandersee, 1993). If teachers are aware that children come to school with a variety of scientist perceptions, they can use this knowledge to help young children accurately understand what scientists look like, where they work, and what they do. On the other hand, children need opportunities to voice the perceptions they have about the world in which they live. Allowing children in all cultures to voice those perceptions provides educators with an opportunity to correct misunderstandings and hopefully influence children to consider scientists and science differently.

Conclusion

This research illustrates the distinct differences in the beliefs of elementary students in the United States and China regarding their perceptions of scientists and the activities in which scientists are involved. For decades, researchers were convinced that one stereotypic image of scientists existed among children worldwide. But today, with the development of advanced testing methods, we are able to extract more information from children's portrayals of scientists. By examining multiple pictorial representations with a multidimensional rubric, distinctions can be established and researchers can begin questioning why children from different cultures view science so differently.

Recommendations

Educators in the United States and China need to emphasize the fundamental elements of inquiry in their classrooms and its connection to the nature of science and scientific work. They also need to assist students in understanding and appreciating the characteristics of scientists—their appearance, the places they conduct science activities, and the processes associated with science.

Using instruments like the E-DAST can assist educators and education researchers to further investigate student perceptions of scientists within each culture. Lastly, more research needs to be conducted regarding the cultural differences of students worldwide as a means of deepening our understanding of how students' perceptions of scientists evolve and mature.

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Appendix A

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.

Appendix B

Description of Scoring Categories in the DAST Rubric

Appearance

Illustrations which score a "1" in Appearance can be labeled as "Sensationalized." These drawings contain a man or a woman who may resemble a monster or who has clearly an odd or comic book-like appearance. Illustrations which score a "2" in Appearance can be labeled as "Traditional." These drawings contain a standard looking white male. Illustrations which score a "3" in Appearance can be labeled as "Broader than Traditional." These drawings include a minority or woman scientist. Illustrations which score a "0" in Appearance can be labeled as "Can't Be Categorized." These drawings may contain a stick figure, a historical figure, no scientist, or a teacher/student.

Location

Illustrations which score a "1" in Location can be labeled 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 labeled 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 labeled 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 labeled as "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 labeled 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 for which the student writes, "[T]his scientist is studying . . . or trying to . . ." but does not show how this is being done. Illustrations which score a "3" in Activity can be labeled 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, "[T]his scientist is studying . . . or trying to . . . and shows how this is being done. Illustrations which score a "0" for Activity can be labeled as "Difficult/Unable to Determine."

The Appearance Category

If a category is labeled "Limited," it means the child illustrated a narrow representation of the category. For example, if a child's cumulative Appearance category is labeled "Limited," it means that the cumulative score of all three pictures was between a 3 and a 4.5 in this category and suggests the child drew very similar appearances of all three scientists. Most likely, the child drew very stereotypical appearances of scientists on each opportunity. If a child's cumulative Appearance category is labeled "Competing," it means that the cumulative score of all three pictures was between 4.5 and 7.5 and suggests that the child holds very different perceptions of scientists which compete within his or her understanding of what scientists look like. Most likely, the set of three pictures include a stereotypical representation of the appearance of a scientist and a nonstereotypical representation of the appearance of a scientist. If a child's cumulative Appearance category is labeled "Expansive," it means that the cumulative score of all three pictures was between 7.5 and 9 and suggests the child holds very robust ideas about the appearance of scientists. Most likely, the child included women in his or her pictures or multiple scientists in more than one picture.

The Location Category

If a category is labeled "Limited," it means the child illustrated a narrow representation of the category. For example, if a child's cumulative Location category is labeled "Limited," it means that the cumulative score of all three pictures was between a 3 and a 4.5 in this category and suggests the child drew very similar locations in all three pictures. Most likely, the child drew very stereotypical locations of scientists, like basements, on each opportunity. If a child's cumulative Location category is labeled "Competing," it means that the cumulative score of all three pictures was between 4.5 and 7.5 and suggests that the child holds very different perceptions of the places where scientists work. Most likely, the set of three pictures include a stereotypical representation of the location (basement) of a scientist and a nonstereotypical representation of the location (outdoors) of a scientist, or just had three traditional pictures of a scientist working in a laboratory setting. If a child's cumulative Location category is labeled "Expansive," it means that the cumulative score of all three pictures was between 7.5 and 9 and suggests the child holds very robust ideas about the location of scientists. Most likely, the child included the possibilities of outdoors into his or her perception of where scientists work and carried this through to more than one picture.

The Activity Category

If a category is labeled "Limited," it means the child illustrated a narrow representation of the category. For example, if a child's cumulative Activity category is labeled "Limited," it means that the cumulative score of all three pictures was between a 3 and a 4.5 in this category and suggests the child drew very similar activities for all three scientists. Most likely, the child drew stereotypical representations of the activities done by scientists on each opportunity. If a child's cumulative Activity category is labeled "Competing," it means that the cumulative score of all three pictures was between 4.5 and 7.5 and suggests that the child holds very different perceptions of the activities done by scientists, which compete within their understanding of what they do. Most likely, the set of three pictures include a stereotypical representation of the activity of a scientist and a nonstereotypical representation of the activity of a scientist. If a child's cumulative Activity category is labeled "Expansive," it means that the cumulative score of all three pictures was between 7.5 and 9 and suggests the child holds very robust ideas about the activity of scientists. Most likely, the child included women in his or her pictures or multiple scientists in more than one picture.