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Moving Beyond the Lone Scientist: Helping 1st-Grade Students Appreciate the Social Context of Scientific Work Using Stories About Scientists

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Abstract

While several studies have documented young children's (K-2) stereotypic views of scientists and scientific work, few have examined students' views of the social nature of scientific work and the strategies effective in broadening these views. The purpose of this study is to examine how stories about scientists influence 1st-grade students' views of the social nature of scientific work. Analysis of student work, drawings, and semistructured interviews indicate that students developed an appreciation for three aspects of the social nature of scientific work: (1) scientists work collaboratively, (2) scientists communicate with the public, and (3) scientists draw on socially constructed resources.

Introduction

Students' views of the nature of science (NOS), including their views of the social nature of scientific work, are widely accepted as important aspects of their scientific literacy (Driver, Leach, Millar, & Scott, 1996; Hodson, 1998; Lederman & Lederman, 2004; National Research Council [NRC], 1996). According to the National Research Council (NRC) (1996), students from the kindergarten level are expected to develop awareness that science is a human endeavor conducted by teams of scientists and engineers. The social dimension of scientific work was also identified by Osborne, Collins, Ratcliffe, Millar, and Duschl (2003) as one of the nine themes encapsulating key ideas about the NOS for which there was consensus from 23 leading international experts in science education, science, and science studies.

Several studies have documented young children's (K-2) stereotypic views of scientists and scientific work (Barman, 1997; Finson, 2002; Fort & Varney, 1989; Mason, Kahle, & Gardner, 1991; Newton & Newton, 1998). These studies have found that students perceive scientists as white, balding males who wear spectacles and lab coats and work indoors with chemicals. Few studies, however, have examined early primary students' (K-2) views of the social nature of scientific work and the use of strategies designed to broaden these views.

Statement of the Problem

Most research conducted on junior elementary, intermediate, and senior students' views of the social nature of scientific work have found that students possess a stereotypic image of scientific work as *asocial*—an individual rather than a collaborative endeavor (Driver et al., 1996; Finson, 2002; Flick, 1990; Matthews & Davies, 1999). Such an image of scientists is alienating for many students, contributes to students' inauthentic views of scientific practice, and promotes a view of the scientific community that is exclusive and restrictive rather than inclusive. It is important to study the effectiveness of strategies that could be used to broaden the views of early primary students as researchers have suggested that stereotypes of scientists form early (i.e., by ages six or seven) and strategies intended to change student perceptions are often applied too late when students' views are more resistant to change (Finson & Thomas, 2006; Newton & Newton, 1998).

The data presented in this article derive from a larger qualitative study which examined how stories about scientists presented over 13 40- to 50-minute lessons using an explicit and reflective approach influence 1st-grade students' views of scientists and the nature of scientific work (Khishfe & Abd-El-Khalick, 2002). Following a naturalistic research paradigm (Lincoln & Guba, 1985), the following research questions were used to guide the collection and analysis of the data presented in this article: (1) What are students' views of the social nature of scientific work (i.e., Do students view science as an individual or social endeavor?), and (2) How do stories about scientists influence students' ideas about the social nature of scientific work?

Previous Research on Students' Views of the Social Nature of Scientific Work

Of the strategies used to ascertain students' images of scientists and scientific work, the most commonly used, especially for primary students, is the Draw-a-Scientist-Test (DAST) (Chambers, 1983). In this method, students are invited to draw a scientist, and their drawings are analyzed to determine students' views of what scientists are like as people, what scientists do, where they work, and if they work alone or with others (Finson, 2002). The instructions Chambers (1983) used in administering the DAST were modified in subsequent studies. Instead of asking students to just "draw a scientist," for example, Huber and Burton (1995) asked students to "draw a scientist at work." Through a pilot study, they found that this alteration in the instructions resulted in more detailed drawings. This modification has been incorporated in the administration of the DAST for the present study. Despite the reliability and the ease with which the DAST can be administered, its validity has been questioned by several researchers on the premise that students' drawings of scientists could reflect their knowledge of the public stereotypes of scientists rather than their personal knowledge and beliefs about scientists (Solomon, 1993; Symington & Spurling, 1990). Hence, it is useful to draw on multiple data sources in addition to the DAST and to explicitly ask children if their drawings depict real scientists.

Using the DAST as the primary data source, studies on elementary students' views of the social nature of scientific work have found that the most prevalent view of the social context of scientific work, even amongst older students, is that science is an individual pursuit conducted by scientists working in isolation

(Driver et al., 1996; Finson, 2002; Flick, 1990; Matthews & Davies, 1999). In their study of junior and intermediate students ages 9, 12, and 16, for example, Driver et al. (1996) found little evidence that students see science as a social enterprise.

A large-scale study by Matthews and Davies (1999) utilized a modified version of the DAST and asked 1st- through 6th-grade students to draw two scientists working under the assumption noted by Matthews (1996) that this modification would give students the opportunity to include a drawing of a female scientist in addition to a male scientist even if they envisioned a male scientist as being more likely to be a scientist. The authors emphasize that they did not instruct students to draw scientists working "together" in order to ensure that students felt free to draw either two scientists working alone or collaboratively. Despite these modified instructions, the authors concluded that students do not perceive science as having a marked social dimension. Of the 1st-grade students who took part in the study, 60 to 66% drew scientists working alone. An asocial view of scientific work has also been found in teachers. McDuffie (2001), for example, found that elementary preservice and inservice teachers depicted scientific work as solitary and "devoid of social interactions" (p. 17).

Intervention studies aimed at helping students broaden their views of the social nature of scientific work are limited. Using the modified instructions for the DAST advocated by Matthews (1996), which specifically ask students to draw two scientists, Harrison and Matthews (1998) found that after 4th-grade students completed detailed work on the lives of six scientists from a range of backgrounds, 12 of the 29 students drew a picture of scientists working together.

Pedagogical Approaches Used to Broaden Students' Views of the NOS

Pedagogical approaches used to broaden or modify students' views of the NOS can be characterized as either explicit or implicit (Khishfe & Abd-El-Khalick, 2002). More recently, a reflective dimension has been added to the explicit approach to emphasize the role of analyzing learning activities, making connections between these activities and the work of scientists and creating generalizations about the epistemology of science (Khishfe & Abd-El-Khalick, 2002). While an *implicit approach* assumes that students will gain an adequate understanding of the NOS simply from engaging in scientific inquiry, the *explicit approach* emphasizes the importance of recognizing NOS ideas as specific learning outcomes that teachers intentionally teach and assess (Khishfe & Abd-El-Khalick, 2002; Kim, Ko, Lederman, & Lederman, 2005).

While there is little evidence for the effectiveness of the implicit approach (Khishfe & Abd-El-Khalick, 2002), several studies to date have suggested that an explicit approach can be effective in improving students' understanding of the NOS (Akerson & Abd-El-Khalick, 2005; Akerson & Volrich, 2006; Carey, Evans, Honda, Jay, & Unger, 1989; Khishfe & Abd-El-Khalick, 2002; Ryder, Leach, & Driver, 1999). In this study, the presentation of the stories was informed by an explicit and reflective approach. Students' views of the social nature of scientific work were specifically targeted as cognitive outcomes that were assessed at the beginning and end of the study. Moreover, students were consistently encouraged to make links between the activities they conducted in class to the work of the scientists presented in the stories.

Design and Procedures

Participants

Eleven 1st-grade students (four males and seven females) and their classroom teacher in a low socioeconomic, multiethnic K-6 school located in an urban city in Ontario, Canada, participated in this study. All students who participated in the study represented visible minorities and were from diverse ethnic backgrounds such as Sri Lankan, Chinese, Filipino, and East Indian. All students spoke languages other than English at home (e.g., Urdu, Tamil, Cantonese, and Tagalog) whose reading, writing, and oral abilities in English were considered "average" by their classroom teacher. It is important to note that all names of students used in this article are pseudonyms.

Instructional Context

Students' views of the social nature of scientific work were assessed at the beginning and end of the study. Since all students depicted scientists as working alone at the beginning of the study, the social nature of the work of scientists featured in the stories was highlighted alongside other aspects of the nature of scientific work (e.g., what they do and where they work). Nine stories about scientists were presented to students over 13 40- to 50-minute lessons from February to June. The following scientists were featured in the stories presented: Kathleen Dudzinski (Dudzinski, 2000), Jane Goodall (Ferber, 1997; National Geographic Society, 1997), Sephen Hawking (Hawking, 1989; Sakurai, 1996), Mae Jemison (Sakurai, 1995), Frank Begay (St. John, 1996), Rachel Carson (Burby, 1997), George Washington Carver (Aliki, 1965), Geerat Vermeij (Vermeij, 1996), and Khalil and Judy (fictional scientists from an unpublished story). Since an important goal of the study was to broaden students' views of the social nature of scientific work, the scientists in the stories were featured working collaboratively with other scientists.

The Role of the Classroom Teacher and Researcher

The classroom teacher and I (the researcher and author of this article) worked together to implement stories and activities and record observations. To reduce the classroom teacher's workload, I took the initiative to locate the stories and related resources. However, the classroom teacher was invited to provide input regarding the choice and/or presentation details of the stories and follow-up activities. I told the stories and engaged students in follow-up discussions. Both the teacher and I worked with students during the follow-up activities, circulating around the room, asking and answering students' questions.

The Presentation of the Stories

The presentation of the stories incorporated the following three parts: (1) an introduction, (2) storyreading/telling, and (3) large group and independent follow-up activities.

1. *Introduction to the Stories*: To invite students to articulate some of their ideas about scientists and science, the presentations of stories were typically preceded by questions or a prop to stimulate students' interest and to help focus their attention.

2. *Storyreading/telling*: The stories were presented using a combination of reading (from picture or biographical books) and storytelling. Videotapes—in the case of Jane Goodall and Stephen Hawking—were used to supplement the storyreading/telling. When the text included in the storybook was too dense or linguistically advanced, I would stop reading and either omit segments (when deemed too detailed or not relevant to the goal of the lesson) or paraphrase the text to reduce its cognitive and linguistic demands. During the stories, students were invited to share comments or ask questions.

3. *Large Group and Independent Follow-up Activities:* Following each story, there was a large group follow-up discussion and an independent or small group activity. The purpose of the large group discussion was to promote reflection on the social nature of scientific work and to help students make explicit connections between the social dimensions of their classroom investigations and the work of the scientists featured in the stories. Students were also guided in retelling some of the stories and presenting them to students outside of the class (i.e., the students' 3rd-grade reading buddies and a class of kindergarten students).

Independent, small group activities were incorporated to personalize the stories by giving students an open space to reflect on what they learned or found interesting about the story and to encourage students to make connections between themselves and the lives and work of the scientist featured in the stories. Hence, in addition to the large group follow-up discussions, students were often invited to draw/write a more open-ended personal response in their journals. The following instructions were often used as prompts for students; however, it was communicated to students that they could also draw and write about anything that related to the story as they wished:

- Draw and write about what you found interesting.
- Draw and write about what you learned from this story.
- If you were the scientist, what kind of questions would you want to ask?
- Draw a scientist of your choosing.

At times, students were also invited to retell the story or tell a story about a scientist of their choice to a partner or small group.

Data Collection

Multiple data collection methods informed the study. Semistructured interviews of students and their classroom teacher were conducted at the beginning and end of the study. As part of the pre-and post-interviews, students were asked to describe scientists, provide an example of a scientist, and indicate if they think scientists work alone or with other people. Pre- and post-interviews of the classroom teacher were also conducted to hear her observations and perspectives on students' views of scientific work.

The DAST (Chambers, 1983) was administered at the beginning and end of the study. Students were given an 8½ × 11 sheet of white paper and asked to draw scientists at work rather than simply "a scientist" as suggested by Matthews (1996). The classroom teacher and I asked students to describe their drawings, and we recorded what they said verbatim onto their sheet. Given the validity issues identified by Solomon (1993), we encouraged students to talk about their pictures and specifically asked if their pictures represented a real scientist doing real science work.

Given the general assumption that young childrens' writing can tell us something about their beliefs and views of different aspects of the world (Eiser, Eiser, & Mattock, 1990), students were asked to tell a story about scientists at the beginning and end of the study. Students were told that the purpose of the storytelling task was to hear their ideas about scientists. Some of the childrens' stories were audiotaped and transcribed, and others were typed into a computer as students told their stories. When necessary, students were asked questions for the purpose of clarification and to encourage them to provide more details. Other data sources included students' follow-up activities (e.g., students' science journal entries) and fieldnotes.

Data Analysis

Each data source was reviewed and analyzed for evidence of a collaborative view of scientific work (i.e., depiction of scientists working together). Review of the data revealed that some students had expressed what Driver et al. (1996) referred to as the *external* social context of scientific work. While the *internal* social context of scientific work refers to the collaboration between scientists and technologists within the scientific community, the *external* dimension highlights the social interactions that occur between scientists and the public (i.e., those external to the scientific community). Hence, the internal and external social contexts of scientific work identified by Driver et al. were used as categories in the coding of the data. Students' appreciation of the need for scientists to draw on various socially constructed resources (e.g., books and the Internet) was identified using an inductive coding technique based on grounded theory (Strauss & Corbin, 1998). After the identification of this latter category, each of the data sources was reexamined and analyzed for evidence of an expressed view of the three dimensions of the social nature of scientific work: (1) external, (2) internal, and (3) social resources. Students' views belonging to each category were marked using a colour-coding scheme. Results from each category were then tabulated to compare students' views at the beginning and end of the study.

Students' views were categorized as expressing an awareness of the internal social context of scientific work if they depicted a scientist in any of the data sources working with one or more scientists in any work context (e.g., fieldwork, asking each other questions). Representations of scientists sharing their work or interacting purposefully with members of the public were classified as views of the external social context of scientific work. Students' views were categorized as expressing an awareness of the need for scientists to draw on social resources if they depicted scientists seeking ideas from socially constructed resources such as books, the Internet, or magazines.

Insight into the first research question (i.e., whether students view scientific work as an individual or social endeavor) was gained through the analysis of the data collected at the beginning of the study. A comparison of the changes in students' views corresponding to each of the three categories of social nature of scientific work shed light on the second research question (i.e., how the presented stories influenced students' views of the social nature of scientific work).

Findings

At the beginning of the study, students depicted scientists as individuals who work alone. With the exception of one student (Kumar, noted later) who drew a picture of a scientist writing a book about dinosaurs, no other evidence of the social context of scientific work was evident in the data collected at the beginning of the study. Some evidence for an awareness of each of the three dimensions of the social nature of scientific work was noted at the end of the study. Results for each of the three dimensions are discussed next.

I. Scientists Working with Other Scientists (Internal Social Context)

While no student at the beginning of the study expressed a collaborative view of scientific work, eight of the 11 students did so at the end of the study. For example, when asked at the end of the study where scientists work, Shruti's explicit response indicates her awareness that some scientists work together:

Interviewer: *Where do scientists work?*

Shruti: *With children, with adults, and other groups of scientists.*

Similarly, the following story by Loula about two scientists working together to construct and figure out the identity of a dinosaur they found suggests that she has developed an appreciation for the need for scientists to collaborate when conducting fieldwork and their need to draw on socially constructed sources of knowledge:

> Once upon a time, there was a girl and a boy. They were scientists. And the girl's name was Azza and the boy's name was . . . [silence]
>
> Interviewer: *And what did they do?*
>
> Loula: *They did—they took dinosaurs' bones and they fixed [them] so they could see how—what dinosaur is that.*
>
> Interviewer: *And then what happened?*
>
> And then, and then they find a different piece and they build it, but it was T-Rex. And they thought how do T-Rex get bigger and bigger. They went home and sit down and think and they think and think. And they could not get the answer. And they tried to look at the computer or at the books, but they could not find the answer. And they asked each other questions: How do dinosaur grows up? What food do dinosaur eats?

II. Scientists "Communicating" with the Public (External Social Context)

At the beginning of the study, only one student indicated an appreciation of scientists engaged either directly or indirectly (e.g., via writing) with the public. For example, Kumar depicted a scientist in his DAST writing a book about dinosaurs. At the end of the study, five students expressed this view. For example, Renu depicted the scientist in her story receiving questions from people in the community. It is interesting to note that a book is produced by the scientist as a result of this work—a resource that will then reach others in the wider community. Part of her story is as follows:

> . . . So when she was a scientist, she was like: go to people's house and take their questions and she asked why do you think, and when they try to figure it out, she put them in the book . . . .

The following story by Shruti also indicates an appreciation for the work of a scientist reaching other people and an awareness that the work of scientists contributes to the education of the public:

> Once upon a time, there was a girl named Sally. Sally was curious about dolphins and other nature things. So she started to write a story about them. Then, one day, she gave it to a magazine, and people read it and they learned lots of things . . . .

III. Scientists Drawing on Socially Constructed Sources of Knowledge

While no student at the beginning of the study depicted a scientist drawing on a social resource such as books, magazines, or the Internet, at the end of the study, three students' post-stories depicted one or more scientists searching for ideas and answers in books and on a computer. In addition to Loula's story (told previously), at the end of the study, Renu tells the story of a scientist who ". . . looked inside the library, and she couldn't find the answer. She looked inside the computer—well she could only find one answer. Then she looked inside the books. Then she saw many answers."

Discussion and Classroom Implications

The asocial nature of scientific work expressed by the students at the beginning of the study are similar to those documented by researchers who have found that the majority of students—from the elementary to the secondary level—perceive the work of scientists as being very solitary and lacking in social interaction (Driver et al., 1996; Finson, 2002; Flick, 1990; Matthews & Davies, 1999). However, the views expressed by the 1st-grade students at the end of the study are more in line with those advocated by reform efforts and science educators (Hodson, 1998; Lederman & Lederman, 2004; NRC, 1996; Osborne et al., 2003).

Like the 4th-grade students in the study by Harrison and Matthews (1998), the 1st-grade students in this study showed improvement in their awareness of the collaborative nature of scientific work. However, in this study, some of these 1st-grade students also depicted scientists interacting with others outside the scientific community and the need for scientists to actively draw on various social resources. To date, there has been limited documentation of young children's appreciation of the social interactions between scientists and the public and students' awareness of the need for scientists to draw on social resources.

This study has implications for teachers interested in integrating stories about scientists and their work—namely, the recognition that stories can be exploited as instructional strategies to enrich students' views of the social nature of scientific work. The potential of stories was also noted by Farland (2006) who found that historical nonfiction trade books helped 3rd-grade students broaden their views of the appearance of scientists, the activities they do, and where they work. The gains made by the students in this study suggest that using an explicit and reflective approach as advocated by several researchers (Akerson & Abd-El-Khalick, 2005; Akerson & Volrich, 2006; Khishfe & Abd-El-Khalick, 2002) can help young children make connections between the social dimension of their school science, the work of scientists depicted in stories, and the work of scientists at large. Osborne et al. (2003) also emphasize the following point when in describing strategies that could support the teaching of the nature of science they assert,

> . . . unless there is some careful mediation on the part of the teacher across lessons . . . to highlight the methodologic features of these activities and their generic nature explicitly, many aspects of a more accurate picture of the nature of science may be glimpsed only partially, if at all, by students. (p. 716)

Limitations and Further Research

It is important to note that this study did not aim to control the myriad of variables that could influence student learning about the nature of scientific work. Hence, despite the observation that the post-study data (i.e., DAST, interviews, and student stories) suggest that students drew extensively on various aspects of the stories (e.g., names of scientists presented in the study and subject matter studied by the scientists such as dolphins and black holes) when they presented their views about science and scientists at the end of the study, it is not possible to attribute changes in students' views exclusively to the stories presented. Students were exposed to numerous out-of-class influences that could have contributed to the shifts they expressed at the end of the study. Future large-scale studies utilizing an experimental approach may provide further useful data on the impact of stories about scientists on students' views of the nature of scientific work.

Moreover, this study involved a small sample in a very specific context. Hence, while these findings are useful in highlighting some of the possible benefits of using stories about scientists for helping 1st-grade students develop more inclusive images of scientific work, the results cannot be generalized beyond these participants. Also, it is not clear from this study whether students will retain the images of science; studies which integrate delayed post-interviews could shed some light on this.

Concluding Thoughts

Lifelong scientific literacy begins with attitudes established in the earliest years (NRC, 1996). A science education committed to "scientific literacy for all" (American Association for the Advancement of Science [AAAS], 1998, p. 1) is one committed to helping students broaden their images of scientific work and ensuring that they are not alienated by stereotypic images of scientific work (e.g., scientists working in isolation). Helping students to view scientific work as collaborative and helping them appreciate the need for scientists to draw on such socially constructed knowledge may provide them with an important foundation for appreciating the socially constructed nature of scientific knowledge—a widely accepted view of the nature of scientific knowledge. This study contributes to the limited literature exploring interventions aimed at modifying early elementary students' views of the nature of scientific work. It suggests that stories about scientists who work in a social context, presented to primary students (e.g., 1st-grade students) using an explicit and reflective approach (Akerson & Volrich, 2006; Khishfe & Abd-El-Khalick, 2002), can contribute to helping students move beyond the image of the lone scientist working in isolation (Driver et al., 1996; Finson, 2002; Flick, 1990; Matthews & Davies, 1999) to a more inclusive image of scientists working collaboratively with others and connected to society in meaningful ways.

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