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Comparing Science Teaching Styles to Students' Perception of Scientists

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Many educational researchers seem to concur with the idea that, among other factors, the teacher's teaching style has some impact on student learning and the perceptions students develop about science learning and the work of scientists. In this study, nine middle grades teachers' teaching styles were assessed using the Draw-a-Science-Teacher-Teaching Test Checklist (DASTT-C) and categorized along a continuum from didactic to inquiry/constructivist in orientation. Students' (n = 339) perceptions of scientists were determined using the Draw-a-Scientist-Test Checklist (DAST-C). Teachers' teaching styles and their students' perceptions of scientists were then compared using nonparametric correlational methods. Results showed that no significant correlation existed between the two measures for the population studied. Although the study provides no understanding about when or how relationships developed between teachers' teaching styles and students' perceptions of scientists, trends in the results give rise to some concerns regarding the preparation of future science teachers and the in-service development of practicing teachers.

Drawing from one's own science classroom experiences as a student, as well as from observations of science teaching (whether it be one's own or that of others), it is not unreasonable to conclude that–among other factors — the teacher's teaching style has some impact on student learning and the perceptions students develop about science learning and the work of scientists. One may argue that teachers who are more constructivist and inquiry oriented in their teaching will have students doing "science" similar to the way scientists actually conduct their work (American Association for the Advancement of Science, 1990; National Research Council, 1996). Conversely, teachers who are more expository and didactic in their approaches will have students engaged in learning that is less like scientists' actual work. The teaching style teachers use may arise from their personal beliefs and self-efficacy about science teaching and their perceptions regarding the work of scientists.

Teacher Beliefs

It is well documented that preservice teachers hold vivid images of teaching based upon their experiences as students (Calderhead & Robson, 1991). These experiences influence the way in which preservice teachers translate knowledge and envision the practices they apply as teachers (Thomas, Pedersen, & Finson, 2001). In at least some instances, individuals appear to form beliefs early in life about what classrooms and traditional teaching should look like, and those beliefs are acquired and perpetuated through cultural transmission (Pajares, 1992). Nespor (1987) further described that an individual's experiences or critical episodes influence beliefs that ultimately frame how individual teachers form their teaching practices. It would seem that experiences, critical episodes, and knowledge are then developed and organized in the form of personal theories that help preservice teachers make sense of their world as they interact with children (Rodgers & Dunn, 1997). Clearly, preservice teachers enter education programs already having a fairly well-formed collection of beliefs, including those about the nature of science, how students learn, and what strategies may be best applied in a teaching-learning environment (Thomas & Pedersen, 2003).

Simmons et al. (1999) confirmed this notion and described in their study that teachers graduate from their teacher preparation programs with a range of knowledge and beliefs. They went on to state that these

beliefs include

> ...how teachers should interact with subject content and processes, what teachers should be doing in the classroom, what students should be doing in the classroom, philosophies of teaching, and how they perceived themselves as classroom teachers. Beginning teachers described their practices as very student-centered. Observed teaching practice contrasted starkly with teacher beliefs; while teachers professed student-centered beliefs, they behaved in teacher-centered ways. (p. 931)

The difficulty, it seems, is that preservice teachers pick and choose those experiences, critical episodes, and knowledge that confirm their preexisting personal theories and beliefs, while those that conflict are ignored (Ulrich, 1999). Kagan (1992) further suggested that preservice teachers may not even be consciously aware of their own theories, and the derivation of their personal theories may come from only one or two models. Unfortunately, many preservice teachers' K-12 experiences involve text-driven instructional models (i.e., dependent upon teacher lectures and demonstrations; Tobin, Briscoe, & Holman, 1990), and their college courses (including science methods courses) contribute to this same perspective of teaching and learning (Lortie, 1975; Raizen & Michelsohn, 1994; Spodek, 1988).

Once in the classroom with their own students, the pressures of the school culture and preexisting beliefs and images bear on their practice, typically furthering their tendency to teach in traditional ways (Kagan, 1992). These practices are steeped in the teacher's own "views of children and how they learn and tend to resist change" (Rogers & Dunn, 1997, p. 12). It is possible that the personal beliefs of teachers remain so obstinate because they are reflections of deeply held personal theories about knowledge and the learning process and are often difficult for the individual to discover (Rogers & Dunn, 1997). In essence, teachers tend to teach in the same ways in which they were taught when they were students, and their perceptions about science and science teaching and learning are influenced by their own experiences as students. Consequently, one could reasonably infer that what students learn in the science classroom about science and scientists is impacted by the ways their own teachers teach about science and scientists.

Self-Efficacy

According to self-efficacy research, teachers who believe they have the ability to perform what are viewed as good quality science teaching behaviors are more likely to utilize instruction mirroring those qualities. Teachers who hold such beliefs are more likely to deliver instruction that engages children in actively constructing knowledge, using this knowledge to promote effective functioning within their ever-changing environments. This inquiry approach mirrors the way scientists conduct their own work. Conversely, teachers who have less confidence in their abilities to teach science tend to utilize more didactic, expository approaches to instruction, which is much less the manner in which scientists actually function in their work (Ramey-Gassert, Shroyer & Staver, 1996; Rubeck & Enochs, 1991). Students will learn what the teacher presents (Eggan & Kauchak, 1994). In each lesson, teachers convey their own particular perceptions about what science is, how it is done, and the people (scientists) who do it.

Teachers who feel capable of teaching via inquiry/constructivist formats tend to be those who have positive attitudes toward science and science teaching, are effective teachers of science, and have students who are successful in learning science (Rubeck & Enochs, 1991). The perceptions developed and held by these teachers' students about science and scientists are often believed to be more positive than are the perceptions held by students taught via more expository, authoritative approaches. The consequence of these differential beliefs is that the former student groups tend to have more positive perceptions of scientists than do students from the latter group, and their images of scientists tend to be less stereotypical (Finson, 2002). Such students are more likely to see themselves in the role of scientists and view such a role as being more positive than negative.

There have been a number of methods for ascertaining students' perceptions of scientists. Over the past decade, a growing body of work has been done with the Draw-a-Scientist Test (DAST) developed by Chambers (1983) to elicit student's images of scientists (Finson, 2003). With the DAST, students are asked to draw a picture of a scientist. Students' drawings are then compared with a list of stereotypical images derived from the extensive research of Mead and Metraux (1957) and later refined by Schibeci and Sorenson (1983) and Finson, Beaver, and Cramond (1995). Finson et al. (1995) took the original DAST and formulated the Draw-a-Scientist Test Checklist (DAST-C), which aids researchers in quantifying image elements and deriving scores to facilitate statistical analysis. In addition, the DAST-C provided increased control for validity and reliability in the measure.

One outgrowth of the work with the DAST-C has been the development and validation of a related instrument for teachers, the Draw-a-Science Teacher Teaching Checklist (DASTT-C), in which teachers are asked to draw themselves "as a science teacher at work" (Thomas, Pedersen, & Finson, 2001). The drawings are then scored using a similar checklist. Scores can be compared to a teaching-style continuum, where expository teaching is at one end and constructivist/inquiry teaching is at the other. The drawings made by both teachers and students might, therefore, be compared to assess the relationship between teachers' perceptions of themselves (didactic-to-constructivist-orientation) and students' stereotypical-to-nonstereotypical perceptions of scientists.

Description of the Study

The purpose of this study was to investigate the relationship between teachers' teaching styles (on a continuum from didactic to constructivist) and the perceptions their students held about scientists (from stereotypical to nonstereotypical). One may hypothesize that constructivist, inquiry-oriented teachers are more likely to have students with perceptions of scientists that are low in their stereotypes.

Subjects

The subjects in the study included two different groupings of individuals: middle grades classroom science teachers and their students (grades 5 through 8). All subjects were from the midwestern United States. Originally, 15 teachers volunteered to participate in the study. One teacher eventually was unable to do so due to health reasons, and 5 were unable to do so because their administrators declined to approve their participation. Consequently, a total of 9 teachers participated in the study. All teacher participants involved had at least 5 years of teaching experience in science. Their teaching experience ranged from 5 to 27 years, with a mean of 15.44 years. Three were male and 6 were female. Four were specifically certified to teach elementary education with concentrations in science, while the other 5 were certified to teach science.

The student population in these 9 teachers' classrooms totaled 624. As in most studies involving human subjects, some students declined to participate. In the end, a total of 327 students participated in the study, or 52.4% of the original potential pool of subjects. Data for each of the 327 students were obtained by the researchers (a 100% return). There were 129 male students (23 in Grade 6, 67 in Grade 7, and 39 in Grade 8) and 198 female students (42 in Grade 6, 91 in Grade 7, and 65 in Grade 8). At the time of data collection, students had been exposed to each of their teachers for a period of between 12 and 13 weeks, depending upon the date the academic years began at each school. Each teacher taught general science to their students during this time period. Although not all teachers taught exactly the same topics or the same sequence of topics, each taught physical science at the beginning of their school years.

Procedures

School districts served by the researchers' universities were identified, and teachers within those districts were invited to take part in the study. Teachers self-selected whether or not to participate. Once teacher participants consented, the researchers visited individually with each teacher to review the research forms and test administration procedures. Researchers provided each teacher a packet, including an informed consent form for the teacher, a copy of the DASTT, a cover letter and informed consent form for each student (complete with space for parent/guardian signature), blank papers for students to use in drawing their scientists, a set of written directions for administering both the DASTT and DAST, and a postage-paid return package. Teachers were requested not to elaborate beyond the prompt when they administered the DAST to students.

Near the end of the school year, teachers completed their DASTT immediately prior to their students completing the DAST. Teachers were directed to discard drawings of students who had not returned consent forms. Teachers then placed all remaining materials in the mailing package and returned them to the researchers. As class sets of drawings arrived, they were coded and then scored using the appropriate checklists. To address interrater reliability issues, all drawings were scored by one of the researchers who has extensive background and experience with coding and scoring such drawings. Subsets of teacher and student drawings were scored by each of the other researchers to ensure appropriate scoring by the primary scorer. An analysis of variance (ANOVA) was completed on the scores of subsets examining the differences between the scores given by the researchers to the drawings. No significant difference was found in any of the subset total scores.

Instrumentation

The two instruments employed in this study were the DASTT-C and the DAST-C.

The DASTT-C. The DASTT-C consists of two parts: a sheet of paper having a large square area outlined on it with the prompt to "draw a picture of yourself as a science teacher at work" and the checklist rubric. The DASTT-C rubric is divided into three sections that focus on the teacher, the students, and the environment. It also includes a section for the subject to write a brief narrative describing and explaining the drawing. The range of possible scores is 0-13. If a particular element on the checklist is present in a drawing, then that element on the checklist is marked. All such marks on a single checklist are then totaled to derive a score for the drawing. Scores are grouped into three ranges on a continuum, with scores of 0-4 representative of teachers who are exploratory in their teaching style, 5-9 representative of teachers who are conceptual in their teaching style but not yet truly constructivist, and 10-13 representative of teachers who are explicit and didactic in their teaching styles.

DASTT-C developers (Thomas et al., 2001) reported the instrument's reliability to be KR-20 = 0.82. The instrument's developers reported that validity was determined via review by a panel of five individuals who examined it for relevance of content.

The DASTT-C's developers were careful to define their use of the terms *exploratory, constructivist*, and *expository/didactic* as follows: Exploratory (or inquiry/constructivist) teaching is represented by student-centered images, in which students are actively engaged and the teacher is guiding or facilitating the learning and in which the students are selecting and pursuing those investigations of interest and importance to them. Conceptual teaching is represented by images showing students at the center, but likely include more teacher images within the central aspects of the images and have them leading the development of concepts or providing information leading directly to concept formation and usually show students engaged in exploration and investigation with materials. Explicit/didactic teaching is represented by images in which the teacher is the central image and one who is predominantly a giver of information, while students are relatively passive and often in desks arranged in rows.

In large part, these definitions parallel those used by Simmons et al. (1999). Note that the "images" include not only the drawn aspects of the subject's image, but also the written narrative aspects of the image held.

In using the DASTT-C, the subject draws a picture of what he or she thinks a science teacher at work looks like. The drawing is then analyzed by a researcher who carefully examines elements of the drawing and scores the number of elements shown in one of three sections on a rubric. The first section looks at the teacher with regard to his or her position (location in class, posture, etc.) and activity (demonstrating, lecturing, using visual aids, etc.), the second looks at the student (the students' activity and positions, e.g., within the classroom or around the teacher), and the third looks at the environmental context in which the instruction is occurring (e.g., arrangement of desks, presence of science equipment, etc.).

For each element present in the drawing, a score of "1" is made on the rubric in the appropriate section. Two or more items in the drawing representing the same element are scored only once. Once all elements are scored, a total for each section and a total for the overall drawing is determined by adding the scores. Possible scores may range from 0 to 13 points. Subranges of these scores are then used to indicate the three teaching styles described earlier in this paragraph.

The DAST-C. The DAST-C also consists of two parts: a blank sheet of paper (the prompt, "draw a picture of a scientist," is typically provided orally by the test administrator) and the checklist rubric. The checklist itself is comprised of 16 items. The first seven focus on the stereotypical elements of drawings identified by Chambers (1983), while the next eight focus on alternative stereotypical images. A final item provides for open comments and descriptors about drawings and is not counted in the scoring. If a drawing contains an element included on the checklist, that checklist item is marked. All such marks on the checklist are then added to provide a score for the drawing. Possible scores range from 0 to 15. The DAST-C developers (Finson et al., 1995) reported the reliability of the instrument to be determined via test-retest procedures and ranged from 0.94 to 0.98.

The validity of the DAST has been established extending back into the early 1980s, beginning with the work of Chambers (1983) and Schibeci and Sorenson (1983). The instrument has been found to have utility across countries (Chambers, 1983); across the nation (Barman, 1996); across cultural groups (Finson, 2003; Sumrall, 1985); across gender (Flick, 1990; Fort & Varney, 1989; MacCorquodale, 1984; Odell, Hewitt, Bowman, & Boone, 1993; Ross, 1993); across age (Odell et al., 1993); in intervention strategies directed at changing the perceptions of subjects with regard to scientists (Finson et al., 1995; Huber & Burton, 1995; Mason, Kahle, & Gardner, 1991; Smith & Erb, 1986); and intervention with preservice teachers (Moseley & Norris, 1999; Reap, Cavallo, & McWhirter, 1994). In short, the DAST has been demonstrated to be

a valid instrument for determining subjects' perceptions of scientists.

Data Analyses

Data were analyzed using several approaches. Nonparametric statistical analyses were used, given the relatively small sample sizes of subjects available. Even though over 300 students produced drawings, the appropriate unit of analysis would be the classroom, and only nine classrooms were included in the study. Consequently, parametric statistics were deemed inappropriate for analysis purposes.

To determine if there was any statistical difference between the students' drawings included in the study, a Kruskal-Wallis one-way ANOVA was conducted. The Kruskal-Wallis analysis does not require normality of distribution of data nor homogeneity of variance for groups under study and is less likely to yield a statistically significant result than would be the case if an ANOVA was employed (Conover, 1980). Means were calculated for each set of class drawings for analysis. Next, a Mann-Whitney U-test was conducted on teacher scores on the DASTT-C to determine if significant differences in teaching styles were present between the teachers participating in the study. Finally, a Pearson Correlation was planned to compare DASTT-C (teacher drawing scores) and DAST-C data (mean scores for class sets of drawings) to determine whether any relationship seemed to exist between the two measures.

The correlation would be necessary to perform for purposes of testing the hypothesis that the stereotypical images of scientists possessed by students is directly influenced by the teaching style of their teachers; or, more specifically, that constructivist, inquiry-oriented teachers are more likely to have students who have perceptions of scientists that are low in their stereotypes.

Results and Conclusions

Teacher scores on the DASTT-C were compared using a Mann-Whitney U-test. DASTT-C scores had a range from 4 to 10 (mean = 6.111, $SD = 1.900$). Teacher drawing scores of 0-4 are classified as "Exploratory" or inquiry/constructivist, scores of 5-9 are "Conceptual," and scores of 10-14 are "Explicit" or expository/didactic (Thomas et al., 2001). The DASTT-C mean for Exploratory teaching was 4.0, the mean for Conceptual teaching was 5.86, and the mean for Explicit teaching was 10.0. Only 1 teacher drawing could be classified as Exploratory and 1 as "expository/didactic." No significant differences in teacher drawing scores were found in the analysis ($U = 48; p < 0.273$).

Kruskal-Wallis procedures were conducted to compare student DAST-C class mean scores to determine if significant differences existed between class on this measure. Scores ranged from a low of 1 to a high of 10 on all student drawings. Results indicated that no significant differences existed between student drawings as measured by the DAST-C ($p < 0.347$). The DAST-C mean for students ($n = 52$) who had an "exploratory" teacher was 5.384. The mean for students ($n = 243$) having a "conceptual" teacher was 5.288, and the mean for students ($n = 32$) having an "explicit" teacher was 5.50.

Since no significant differences were present between either the teachers' drawing scores (DASTT-C scores) or between the student drawing scores (class mean scores of the DAST-C), making comparisons by correlational statistics was inappropriate. Consequently, the study results cannot support the hypothesis that the teaching style of a science teacher has some relationship to students' perceptions of scientists. As noted earlier, the reader should be cautioned in the interpretation of these results since the number of science teachers and the number of classrooms (the unit of analysis for student drawings) involved was relatively small.

Discussion

Although significant differences were expected between those students whose teachers were expository and those students whose teachers were exploratory in their teaching styles, no differences existed in the students' drawings of scientists. Several perspectives can be taken from these results. However, from our view, these results only underscore the perspective that images held by individuals are deeply engrained and resistant to change regarding scientists and science teaching. Results from Pedersen and Thomas (1999) indicated that as early as third grade students' drawings of persons teaching science are similar to those of preservice teachers. That study suggested that early and significant experiences establish frames of reference for children for later use in defining and explaining concepts such as scientists or teaching science. As well, studies have shown that students' views of scientists are developed early, and although they can be changed, they are often static (or resistant to change) as the child ages. What this study did not examine is the origin or nature of the images; rather, the focus was on the current images/perceptions each participant held.

Therefore, the impact of teachers on students' perceptions of scientists appears to be small or insignificant in the cases included in this study, given the relatively short time students spent with particular teachers, as well as the fact that the students were in grades 6-8 (i.e., were old enough to have images resistant to change). This is true even though raw data seemed to indicate a "trend" in which the lowest (less stereotypical) DAST-C scores were for those students whose teacher had the lowest DASTT-C score (classified as exploratory), and where the highest (more stereotypical) DAST-C scores were for those students whose teacher had the highest DASTT-C score (classified as explicit/didactic). It is possible that with larger sample sizes a clearer picture of impact may have emerged. The results would indicate potential for additional research examining the relationship between teacher perceptions of self as science teachers and students' perceptions of scientists. Further research is encouraged that would include larger sample sizes and a larger variance (especially younger participants) in the grade levels used.

Implications for Future Science Teachers

Traditional science teaching methods have survived numerous reform initiatives, including those espoused in the *National Science Education Standards* (National Research Council, 1996), *Science for All Americans: Project 2061* (American Association for the Advancement of Science, 1993), and in various publications of the National Science Teachers Association. This resistance to reform raises meaningful concerns for preservice and in-service teacher education. Critical theory suggests that cultural ways transfer or reproduce themselves from generation to generation — that individuals develop socially and, as a result, cultural ways are "copied" or reproduced and change is resisted (Carspecken & Apple, 1992).

Cultural ways give rise to historic myths that codify school culture and define the tension in resistance to reform. Historic myths about science expository, authoritative teaching are alive and well (e.g., less-than-successful students do not listen, pay attention, or work very hard). Reform-oriented professional development programs need to (a) better define the historic myths held by preservice and in-service teachers, (b) improve opportunities for reflection and discussion about science teaching and learning, and (c) encourage preservice and in-service teachers to resist cultural reproduction — to question the historical distribution of power. Guiding such negotiation beyond the historic myths or assumptions held by the general culture — parents, school board members, administrators, and other teachers — is the primary responsibility of a reform-oriented teacher educator.

Haney, Lumpe, and Czerniak (2003) noted that the persistent view teachers, administrators, parents, and community members have of classrooms looking like traditional classrooms runs counter to efforts to help preservice and in-service teachers be more constructivist oriented in their instructional practices. These persistent views and beliefs are reinforced through cultural transmission, making it difficult for individuals to alter their practices (Pajares, 1992). Consequently, such students enter science educators' classrooms with some built-in resistance to change with respect to constructivist approaches and strategies. If science educators are not well aware of their own students' preferred teaching styles and beliefs in this regard, the task of moving them toward reform-oriented, constructivist approaches may prove frustrating and difficult to achieve.

Science educators may opt to address these issues in various ways. One way may be to help students remember and reflect upon personal episodes in which they experienced hands-on discovery learning that can be clearly and overtly connected to the tenets of constructivism. Such an approach may help preservice and in-service teachers begin to reframe their views of teaching practice (Nespor, 1987; Rodgers & Dunn, 1997). Science educators can carefully design and deliver constructivist instruction in the science methods classroom that provides their students the types of episodic experiences that are critical in the formation of their knowledge development and teaching practice beliefs.

One goal of science educators beyond teaching science effectively is to encourage students to pursue science as a vocation. Much research has illustrated that most students become "turned off" to science around the middle grade years and, thus, fewer and fewer individuals later enter science and science-related careers. The perceptions students hold of scientists and the work they do is often cited as a significant contributing factor to this situation. Science teachers can have notable impacts on their students' attitudes and perceptions if instruction is appropriately planned and delivered.

For example, those who approach the teaching of science in a didactive or explicit manner with little hands-on/inquiry tend to be those whose classes are considered dry and boring by students. This does not necessarily imply that little learning occurs in such classrooms, but the type of learning that occurs may not be what is desired by science educators with an inquiry

or a constructivist orientation. Increasingly, science teacher educators today are concerned with helping their own students (preservice and in-service teachers) move more toward constructivist/inquiry types of instruction, with the ultimate intention of impacting the students in those individuals' classrooms. Teachers who hold beliefs that are in concert with constructivist types of approaches are more likely to teach their own students accordingly, and their students are likely to be willing and able to learn in ways that more closely mirror the manner in which scientists function in their work. Students who can see themselves doing such work and being successful with it have an increased likelihood of pursuing further science coursework in the future and then entering a science related career (Finson, 2002).

Considering all the foregoing discussion, if the teaching style of teachers has any direct or indirect impact on the perceptions students have about scientists, it would be of value for science educators to understand the particulars regarding those relationships. To be aware of the existence of such relationships and factors that may influence them would provide a valuable tool for science educators in the design and delivery of preservice and in-service science instruction. If these types of relationships exist and are not recognized and identified by researchers and then appropriately dealt with, their effects may have subtle yet significant implications with respect to the end results of science instruction as it is presently being promulgated in science education standards. Attention given to either relationship factor (teaching style or student perceptions of scientists) in isolation may not be sufficient in contributing to the attainment of these standards, whereas attention given to the effects produced from the interaction of the two may be. The existence of such a relationship is hinted at in the raw data gathered for this study, but nothing more can be discerned from it due to the problems inherent in the study. Yet the question at the heart of the study hypothesis remains, and answers to it should be sought.

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