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Evaluating Science Education Reform via Fourth-Grade Students' Image of Science Teaching

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ABSTRACT The purpose of this study was to investigate fourth-grade students' image of current science teaching by using a Draw-A-Science-Teacher-Test Checklist (DASTT-C), and give a glance whether the new restructured science education reform in Turkey is implemented successfully or not. Fifty-five (34 girls and 21 boys) fourth-grade students from three different primary schools participated in this study. The results of study showed that 18.2% of Turkish fourth-grade students view their science classrooms as student-centered, 56.4% as neither student-centered nor teacher-centered, and 25.4% as teacher-centered. These results indicate that Turkey is in the process of a big positive change, and that traditional education perspective started switching over to constructivist perspective, while attempts for implementing the reform put emphasis on elementary teachers and their professional development.

KEYWORDS: Curriculum development, DASTT-C, science education reform.

Introduction

Increasingly scientific and technological issues challenge our global society. These issues are affecting the present quality of life. In Turkey as well as in other countries, the science curricula that widely persist in schools are not adequate for developing the knowledge needed to focus on those issues. In the science curricula, students are not engaged in the learning process and typically graduate with little, or at least a shallow understanding of the connections between big ideas and superficial knowledge, and do not have an ability to apply the knowledge to new science concepts and in the real world settings (McCombs & Whistler 1997). As a result, students do not develop the ability to become scientifically literate persons, that is, persons equipped with higher-order cognitive skills.

In Turkey, the recognition of this problem has led to changes in how students are engaged in learning science. After increasing the length of compulsory primary schooling from 5 to 8 years in primary education schools, the Turkish Ministry of National Education has also mandated that all students will achieve scientific literacy, and new curricula for both primary and secondary schools have been implemented since 2000 (Republic of Turkey, Ministry of National Education, 2001).

The new orientation clearly stated that science teachers must establish a learning environment, where safe expression and exploration of ideas and thoughts can occur for both the individual and the group. The new primary education program was based on three essential elements, namely, constructivist theory, multiple intelligence theory, and student-centered teaching. In addition, alternative assessment methods were added to the new teacher education programs, and students began to be more involved with the school science experience (hands-on-activities) (Republic of Turkey, Ministry of National Education, 2000).

Multiple studies focusing on constructivism, teachers' and students' attitudes towards science, scientific literature, and the modified science curriculum has led educators to reconsider the need to examine how teachers are prepared. In addition, several studies examined the results of key international assessments to guide the success or failure of reform efforts. For example, according to the 1999 TIMMS reports, Turkey ranked 33rd out of 38 countries for math and science (TIMSS, 1999), and 39th out of 45 countries for mathematics in the 2003-PISA study (Council of the European Union; OECD Program for International Student Assessment, 2004; Ministry of National Education, 2006). These reports along with the results of studies conducted in Turkey have prompted the government to revise the primary science curriculum in 2004. Even the name of the "science" course was changed to "science and technology" in primary education. The purpose of the revised program is to provide experiences for the children, so that they may understand the nature of science through an active learning environment, using science concepts that are relevant to their lives, needs, and interests (Erdogan, 2005).

The pilot program was implemented in 9 provinces and 120 primary schools in Turkey during the 2004-05 semesters. The Ministry of National Education evaluated the pilot program, so that the program would be appropriately revised and ready for complete implementation at the beginning of the 2005-2006 school year.

This study set out to examine the impact of these reform efforts in a new and unique way. Students who have participated in classrooms, where the new curricula have been implemented, were given the Draw-A-Science-Teacher-Test Checklist (DASTT-C). To date, the DASTT-C has not been used in Turkey to examine the perceptions of primary level students regarding science teaching. The DASTT-C originated from Goodenough's Draw-A Man-Test in 1926. Chambers (1983) developed the Draw-A-Scientist-Test (DAST) as an open-ended projective test to measure children's perceptions of scientists' image. Chambers (1983) used seven standard image indicators to evaluate the scientists' images. The DAST was revised by Symington and Spurling (1990) and named (DAST-R), including 10 indicators, alternative images, and interview questions to investigate science teachers' images and beliefs about scientists and science teachers. Finson, Beaver, and Crammond (1995) modified the DAST in order to further consider alternative images and facilitate ease of assessment as the Draw-A-Scientist-Test Checklist (DAST-C), having 14 indicators. The DAST-C was further modified and included characteristic of science classrooms and science teachers, calling the instrument the Draw-A-Science-Teacher Teaching Checklist (DASTT-C), by Thomas and Pedersen (1998), while it was again modified again by Thomas, Pedersen, and Finson (2001). The main concept of DASTT-C is a listing of teacher-centered and student-centered attributes of science teacher rather than a scientist (Carnes, 2003; Carnes, Brown, Munn, & Shull, 2002; Pedersen & Thomas, 1999; Thomas & Pedersen, 1998a-1998b-2001; Thomas, Pedersen, & Finson, 2001).

Fourth-grade students' images of science teaching were collected and examined using DASTT-C, as they participated in the new science program. The data collected from these students were be used to evaluate the effectiveness of the implementation of the new science program.

Methodology

One hundred twelve fourth-grade students from three different western primary schools in Turkey participated in the data collection at the end of the 2006-07 semester. The instrument took 15-20 minutes to complete. Fifty-seven drawings out of 112 were excluded from the study, because the pictures were not interpretable. The final sample consisted of the remaining fifty-five fourth- grade students (34 female, 21 male). Fourth–grade students were selected for this study because the revised science curriculum was applied for the first time to fourth-grade students.

Instrumentation and Procedures

This study was both quantitative and qualitative in design. Students were given two blank pieces of paper and were asked to "Draw a picture of your science course including teacher and students" in a big square, and explain "what is the teacher doing? What are the students doing?" as outlined on the first page of the DASTT-C instrument. We used DASTT-C as the instrument for this study, but it was modified from the original form, which asks "Draw a picture of yourself as a science teacher at work." Our purpose for making these changes included our belief that fourth-grade students (10-11 years old) would not think themselves as science teachers at work. As well, the intent of the study was to examine what the students were experiencing in their science classroom. The DASTT-C lends itself to this type of data collection and can assist in evaluating how in-service teachers have applied the new science program in Turkish primary science classrooms. Moreover, we also added and asked one question. "*How should your science and technology course be?*" (See Appendix A). Many studies showed that using inquiry and constructivist perspective in science course is the most effective way to teach science, because students can experience the learning of science as a process of doing something or looking at something, and then learning what it means by processing their observations with their classmates. Indeed, research findings indicate that "students are likely to begin to understand the natural world, if they work directly with natural phenomena, using their senses to observe, and using instruments to extend the power of their senses" (National Science Board, 1991, p. 27), while these approaches generally enhance student attitudes toward science in a positive way (Glasson, 1989). It was thus expected that if science teachers follow the requirements of the revised new science program, then fourth-grade students would express, in their narratives regarding their science learning environment, how they like science and technology course.

Although Thomas, Pedersen, and Finson (2001) reported the instrument's reliability to be KR-20 = 0.82, after modifying the DASTT-C, we found the instrument's reliability to be KR-20 = 0.70. The validity was determined via review of drawings by three researchers, including Jon Pedersen.

Table 1
Mean Scores on DASTT-C for Fourth-grade Students

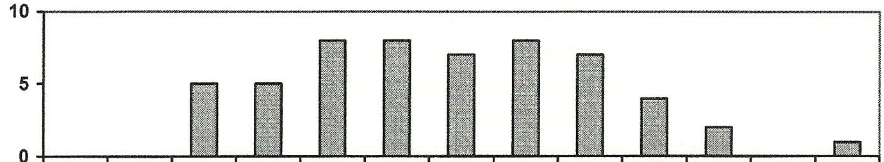
Gender	Female	Male	Total
# of Student	34	21	55
Mean	6.64	7.04	6.8
* Standard deviation: 2.368			

The data were analyzed by tabulating the number of responses for each of the categories and their attributes using the DASTT-C. Each element of DASTT-C is considered by the instrument's developers to depict stereotypical elements of teaching and classroom images. If a stereotypical element appears in a student's drawings, then that element on the checklist is marked. Total checklist scores can range from 0 to 13. Scores are grouped into three ranges on a continuum, with scores of 0-4 representative of *student-centered* teaching style, 10-13 representative of *teacher-centered* teaching style, and 5-9 representative of *neither student-centered nor teacher-centered* (no decision) teaching style (see Appendices B and C).

Analyzing the Data

In the drawings, many students depicted activity-oriented (hands-on) and technology integrated science-learning environments based on a laboratory setting. Science topics or concepts were selected from chemistry more often than other science content areas. Most of the teachers were female and were smiling. Interestingly, outdoor learning environments, individual learning environments, crest-shaped desk arrangements, dramas, lab safety, facial-haired male teachers, and science exhibitions by students were not seen or rarely drawn.

The results of the study indicated that although the majority of the students (56.4%) represented their science classrooms with elements of both student-centered and teacher-centered environments, such as, students actively engaged in the activities, while teachers were most often placed in leading positions in front of the class controlling, for example, a science experiment, as indicated in Figures 1 and 2.



	1	2	3	4	5	6	7	8	9	10	11	12	13
Frequency	0	0	5	5	8	8	7	8	7	4	2	0	1

Figure 1. DASTT-C Frequency

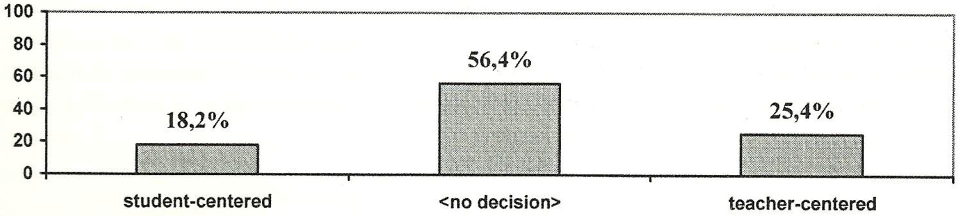
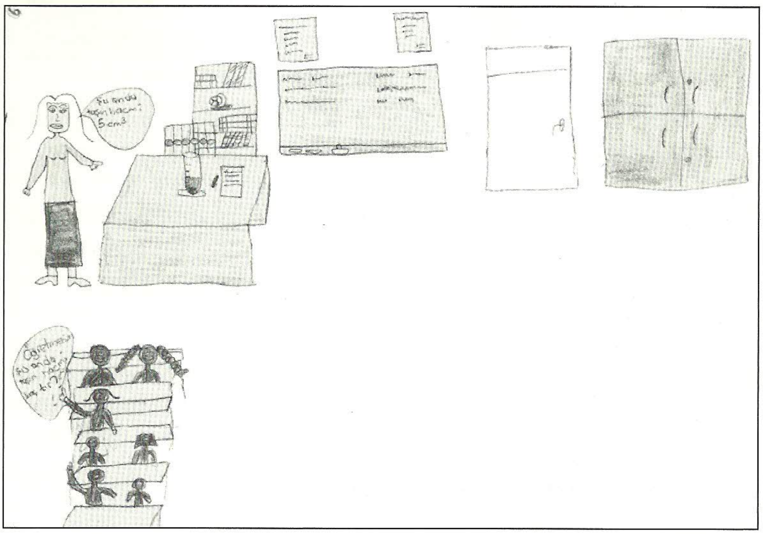


Figure 2. DASTT-C Percentage

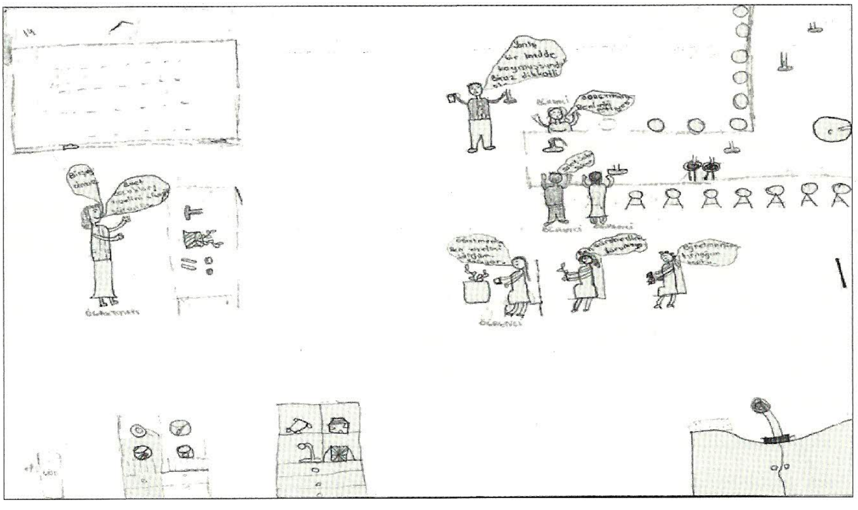
The pictures that represent teacher-centered teaching (10-13 scores) showed teachers establishing order, presenting the rules, and lecturing. They appeared to have absolute authority, transmitted information, and did not provide assistance for students. The students drew themselves sitting in straight rows listening and taking notes on their slates. They often appeared to be passive receivers of information. The types of instruction represented in these drawings include lecturing, students in a passive role, de-emphasizing group work, reading, writing, and student presentations, and, not using concrete models or interdisciplinary lessons, as indicated in Figure 3.



"Techer is lecturing and doing an experiment in front of the class. At the same time, some students are listening and watching their teacher and one of them is asking a question about experiment."

Figure 3. Teacher-centered DASTT-C Picture and Explanation

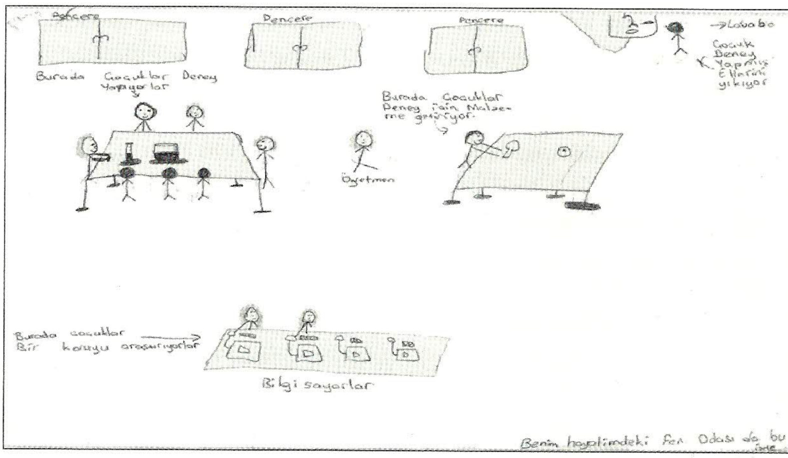
For those drawings that were in the middle range of scores (5-9), the teacher-centered techniques involving the transfer of knowledge can be seen (lecturing, taking notes, writing, videos), as well as student-centered techniques (discussing, drawing, conducting experiments, conducting research, analyzing, planning, collaborating, etc.). Generally, students were carrying out "hands-on activities" in small groups, raising their hands to answer questions, and actively doing an experiment assisted by the teacher. Typically, the teacher was observing groups and may be represented intervening briefly in a group's work to extend students' thinking. The classroom was usually represented with many routine duties delegated to students (Whyte, & Ellis, 2004), as indicated in Figure 4.



"Teacher, standing near her table and in front of the class, is doing an experiment by herself and giving instructions to her students how to do experiment. In a mean time, some of students are sitting and following their teacher's instructions. A group of them, standing around the table a way from their classmates, is studying on a science project in leading one of students."

Figure 4. No Decision DASTT-C Picture and Explanation.

In the drawings, representing student-centered teaching (0-4 scores), the focus was clearly on the learner rather than the teacher. The drawings reflected a constructivist perspective where the students were constructing rather than receiving information. For example, students were represented in the drawings directly involved in inquiry learning through experiences with concepts rather than sitting in a passive manner. This was further verified through the students' descriptions of all the activities. Students in these drawings were working together in groups of three or four with limited teacher guidance, developing lab procedures for the investigation of specific science concepts. The teacher's role in these settings was reflected as a learning facilitator, where students are provided with rich and exciting opportunities for the development of knowledge as a process rather than a product. In most of these drawings, teachers were shown to engage students in recalling what they already knew about the subject. Students were also depicted being involved in an activity that would take them beyond what they already knew. The teacher appeared to actively engage the student in the learning process by focusing the students on doing. Overall the student-centeredness was reflected in these drawings, indicating students to be mobile and working cooperatively on various assignments. Even students who were seating were drawn in unique ways that adapted to discussions or group work (O'Hara, & O'Hara, 1998), as indicated in Figure 5.



"Teacher is standing among the groups of students who are doing experiment and assisting about what the students' needs. A group of students gathered around table is doing experiment, while one student is washing his hands, another is bringing some materials, and two of them are searching on the Internet."

Figure 5. Student-centered DASTT-C Picture and Explanation

For the students' answers of "How should your science and technology course be"?, we categorized their thoughts in seven themes: (1) expectations about making science interesting or enjoyable; (2) expectations about doing many experiments; (3) expectations about being in a science lab; (4) expectations about reducing an overloaded science curriculum; (5) expectations about doing inquiry based science; (6) expectations about using technology especially computers in the lesson; and (7) expectations about having teacher-centered teaching style in their classroom.

For example, one of the students shared her expectation:

> *Buse: Indeed, we do experiments in our science and technology courses, but it is boring, I think science and technology course will be enjoyable and funny, if teacher does many experiments in not limited time and science curriculum should be reduced and suitable to level of students.*

Another student shared his views stating:

> *Melih: I think, in a science and technology class computers, overhead projectors and other type of technologies should be and many types of encyclopedias and books in the bookshelves, because students should do more inquiry outside of school and search in the library. The best way of learning is to hearing and seeing. Thus teacher should teach carefully and do the experiment without mistakes in lab and we watch teacher and learn how to do experiment.*

For a few students' expectations about learning and teaching in elementary science classrooms emerged in four themes; projects, learning outside of the classroom, a smiling happy teacher, silent or individualistic learning environment. For example Begum and Melike stated:

> *"I think students should not be bored in science and technology class and it should be in nature especially in flower gardens. Teacher should not be angry with students when they make mistakes and have always smiling face."*

> *"I think, firstly, teacher talk about science concept and then we search it on computer. After learned science concept we should do experiment and study on projects regarding science concepts. For that reasons, science and technology course will be enjoyable and interesting."*

All the expectations of students can be correlated to a student-centered teaching style, but most of the students expected that teacher should lecture, give directions, and demonstrate the science experiments and activities in the class or lab.

Conclusions and Recommendations

In many ways, one of the hardest things for teachers to accept is a governmental mandate to reform education. Many teachers feel overwhelmed by these dictates and misunderstood by the government. Yet in most cases, the Turkish government has attempted to use current theories of teaching and learning to guide reform towards student-centered approaches for the teaching of science. Around the world today, philosophers and educators suggest that it is time to replant student-centered instruction in the rich fields of science learning (Taylor, Dawson, & Fraser, 1995; Turkmen, 2006; Turkmen, & Pedersen, 2005; Yilmaz, & Huyuguzel, 2006). Turkey has embraced the constructivist view of teaching and learning, which encourages students to predict, explain, debate, defend their ideas, and uses student-centered interaction. It has become the central teaching method prompted in the Turkish education system. As well, the current mandate from the government that all students must become science and technology literate has necessitated new curriculum as well as new approaches. The new Science & Technology curricula emphasize acquiring knowledge on the nature of scientific thinking and processes, the general nature of science and technology, and science-technology-society interactions, and orientate students toward active rather than passive knowledge.

For Turkey, this research is first. The DASTT-C provided valuable insights into fourth-grade students' perceptions of the new Turkish science program. After only one year of implementation, we see this as positive indication of the changing nature of science teaching in our country. According to Louca, Rigas, and Valanides (2002), "good teaching requires a blend of teacher-centered and student-centered skills and deep understanding of when to do what kind of teaching" (p. 247). From that perspective, we found a balanced approach in the classroom that indeed reflects current reform efforts.

Interestingly, a similar dilemma was found within the students' narratives. Most of the students' comments regarding their desired view of science teaching indicated that science and technology courses should be in the lab and be done using educational technology under the directives of their teachers. Students are willing to allow to teacher to decide what is taught and how it is taught, and what approaches to use, but group work and a fun environment are desired in order to carry out projects.

Overall, the result of the current study implies that Turkish teachers are aware of the cornerstone principles of the science teacher reform prompted by the government. Specifically, it seems that teachers are able to implement observation and experimentation and give examples of observation/experimentation in science and technology education. But, it also seems they have difficulties in infusing these concepts completely in their curriculums. In addition, students' drawings and their desired views pointed that the experiments and observations should be done under the direction of teacher. This would indicate that not only teachers need to change and reshape their concept of teaching/learning science but the children need to do so as well.

The hope is that the current research provides a model that reflects another dimension for the evaluation of new Turkish science and technology curriculum that has been mandated in primary schools. Our study was intended to provide a view of the new Turkish science and technology curriculum through "different eyes" (those of the children) in order to characterize the nature of the reform. There might be many reasons why Turkish primary teachers are still one step behind, where the restructured science program is expected to be. As a result, several obstacles must be overcome in order to infuse these reforms into classrooms. We suggest the following actions for the policy makers and teachers:

- This study should be conducted into wider populations that require students to articulate and test their ideas on teaching and learning. Practicum classrooms, student teaching classrooms, or informal science education centers should serve as the setting for the research projects. Even this national study should be compared with other international studies.
- There is a need to reexamine all aspects of science and technology curriculum. Teachers will need the specialized workshops, especially about student-centered teaching style, for professional development and the pedagogical support literature that furthers the science and technology curriculum indications.
- There is a necessity to deepen and expand teachers' understanding and skills about a student-centered approach to science learning. Also teachers should consider some epistemological terms, like, experiment, observation, and understanding. They should not be forgotten learning is long-life learning and outside activities is an important part of science teaching and learning.
- The necessity of coming to clear and attainable science and technology curriculum expectations, as well the proper use of hands-on experiences in teaching, modeled lessons, and the contribution of expert educators.
- Students should be given the opportunity to communicate their views on science teaching and learning with other students, to express, evaluate, and defend their explanations among their peers, and actively engage in the social construction of knowledge.

- Students should be provided frequent opportunity to identify their own learning goals, to share control of the learning environment, and to develop and employ assessment criteria within the learning environment.
- The environment of the classroom should be conducive to inquiry, including the freedom for students to question the operations of their class (Bilgin, & Karaduman, 2005; Caprio, 1994; Craven III, & Penick, 2001; Erdogan, 2005; McCombs, & Whistler, 1997; Staver, 1998; Stevens, Sarigul, & Deger, 2002; Taylor, Dawson, & Fraser, 1995; Turkmen, & Pedersen, 2003).

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Appendix: The Instrument (DASTT-C)

Appendix A
DASTT-C Instrument

Date: ______________________________ ID #: _____ _____ _____ _____

Location: ___________________________ Preservice ( ) or Inservice ( )

Draw a picture of your science course including teacher and students.

What is the teacher doing? What are the students doing?

____

____

____

____

____

____

How should your science and technology course be?

____

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____

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____

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Appendix B
DASTT-C Score Sheet

I. TEACHER

Activity

Demonstrating Experiment/Activity ....

Lecturing/Giving Directions (teacher talking) ....

Using Visual Aids (chalkboard, overhead, and charts) ....

Position

Centrally located (head of class) ....

Erect Posture (not sitting or bending down) ....

II. STUDENTS

Activity

Watching and Listening (or so suggested by teacher behavior) ....

Responding to Teacher/Text Questions ....

Position

Seated (or so suggested by classroom furniture) ....

III. ENVIRONMENT

Inside

Desks are arranged in rows (more than one row) ....

Teacher desk/table is located at the front of the room..........

Laboratory organization (equipment on teacher desk or table) ....

Symbols of Teaching (ABC's, chalkboard, bulletin boards, etc.) ....

Symbols of Science Knowledge (science equipment, lab instruments, wall charts,etc.) ....

TOTAL SCORE (PARTS I + II + III) =

Appendix C
DASTT-C Teaching Styles Continuum

Exploratory (0-4)	Conceptual (5-9)	Explicit (10-13)
1. Teacher believes students are capable of managing their own learning. 2. Curriculum is open to student interests. 3. Teacher leads and guides student activities/ investigations. 4. Teacher focuses on student questions as an instructional goal. 5. Alternative assessment measures student learning and knowledge.	1. Teacher believes students need themed, conceptual learning experiences. 2. Content is exploratory, organized around key concepts. 3. Teacher organizes the connections of content and processes of science. 4. Teacher-centered lessons include hands-on activities, group work, and discussion of ideas. 5. Tests check for understanding of important concepts.	1. Teacher believes students lack knowledge and need assistance in learning. 2. The curriculum is focused on specific outcomes. 3. Teacher is the knowledge conduit (telling is teaching). 4. Teacher initiates activities. Student input is acknowledged but not expected. 5. Tests focus on science content knowledge.
Column total:	Column total:	Column total:

Directions

1. Read across each row. Check the column that best describes your beliefs.
2. Add the check marks in each column.
3. Compare your column totals. How does your teaching style choice align with your DASTT-C score?

Adapted from: Thomas, J. A., Pedersen, J. E., & Finson, K. (2001). Validating the Draw-A-Science-Teacher-Test-Checklist (DASTT-C): Exploring mental models and teacher beliefs. *Journal of Science Teacher Education, 12* (4), 295- 310.