Adolescent Students' Images of an Environmental Scientist: An Opportunity for Constructivist Teaching

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Introduction

Children learn about science from many different sources. Outside school these sources may be books, television programs, and movies. At school, textbooks, science lessons, and teachers' behavior and personalities exert influence on their perceptions of the nature of science and the scientists as persons. Whether they are in school, at home, or in the community, other people may influence children's learning that may include other children as well as adults such as parents, teachers, coaches, or members of the community. The studies by Driver (1983), Osborne and Freyberg (1985), and Fosnot (1989) reported that children have a natural tendency to make sense of their experiences. Chaille and Britain (1991) consider children as theory builders and social beings while Bransford, et al. (2000) characterize children as both problem solvers and problem generators. These researchers assume that children learn actively by constructing knowledge rather than passively taking in information. This constructivist conception of the learner acknowledges the different, more or less complex prior understandings and cultural values that the learner brings to the educational setting (Chaille and Britain, 1991, p. 11). The current study demonstrates that adolescent students' perception of an environmental scientist is a construction of knowledge mediated by learning experiences and prior understandings provided by members of the community.

Mead and Metraux (1957) conducted the first study on high school students' perceptions of scientists' personality and their work. Their study revealed the following image of the scientist.

> The scientist is a man who wears a white coat and works in a laboratory. He is small, sometimes small and stout, or tall and thin. He may be bald. He may wear a beard, may be unshaven and unkempt. He may be stooped and tired. He is surrounded by equipment: test tubes, Bunsen burners, flasks and bottles, jungle gym of blown glass and weird machines with dials. The sparkling white laboratory is full of sounds, the bubbling of liquids in test tubes and flasks, the squeaks and squeals of laboratory animals, and the muttering voice of the scientist. He spends his days doing experiments. He pours chemicals from one test tube into another. He peers rapidly through microscopes. He scans the heavens through a telescope.

> He experiments with plants and animals. He writes neatly in black notebook (p.386).

In 1983, Chambers conducted a study on the images of the scientists involving 4,807 children from kindergarten to grade five in Australia, Canada, and the United States. He developed an instrument known as the "Draw-a-Scientist Test" (DAST) that requires students to draw their mental picture of a scientist. Based partly on the literature, Chambers chose seven indicators of the standard image of the scientist, namely (1) a lab coat, (2) eyeglasses, (3) facial hair (including beard, mustaches), (4) symbols of research: scientific instruments and laboratory equipment of any kind, (5) symbols of knowledge: books and filing cabinets, (6) technology, (7) relevant captions: formula, taxonomic classification, the "eureka" syndrome, etc. From the pictures drawn by the subjects, Chambers (1983) found that the indicators emerge as children progress in grade level. By the fifth grade, a majority of students show at least three or four indicators and a few pictures exhibiting six or seven. In an earlier study by Chambers (1981) (as cited in Schibeci, 1983) he observed a similar trend across socio-economic groups. Children from upper socio-economic groups produced, on average, more indicators than children from lower socio-economic groups. Schibeci (1983) observed a similar trend on the drawings of urban white and rural black children. He found that urban white children averaged more indicators at each grade level than the rural black children. This may be due, in part, to the greater influence of the popular media on the white urban children.

One observation made by Chambers (1983) relates to a scientist's place of work indoors or in underground chambers. He observed that conspicuously absent were drawings of scientist as the naturalist, the explorer, or the scientist who studies nature or the wilderness. Even when scientists are studying how to save the planet, they were doing so in a laboratory. This finding suggests that children strongly associate the laboratory as the place or work of scientists.

On the other hand, Chamber's study (1983) of 4807 children from Australia, Canada, and the United States revealed that very few children (2%) connected the scientist with pollution or the environmental crisis, and most of those children tended to identify scientists as saviors rather than devils. (P.264).

Carter, Stubbs, and Berenson (1996) studied science teachers' images of an environmental scientist at work using the Draw-a-Scientist test. They found that science teachers portrayed the work of environmental scientist as purely collecting data in the field. This finding is similar to the image of a scientist as perceived by college students majoring in biology and liberal studies (Rosenthal, 1993). One fourth of the biology majors in Rosenthal's study (1993) pictured scientists with notebooks that appeared to be associated with data collection. The drawings of biology majors showed a greater variety of research equipment and they are ten times more likely to draw scientists outdoors as were liberal studies majors (Rosenthal, 1993, p. 215). It is interesting to note that in both studies involving the science teachers (Carter et al., 1996) and the biology majors (Rosenthal, 1993), the scientists' activity did not go beyond collecting data. These subjects did not perceive the more important science process skills such as organizing and interpreting data, making generalizations and conclusions as activities of a scientist. Most of the perceptions of science teachers and college students depicted that science is an act of investigation and the manner in which scientists conduct science by experimenting and collecting data.

The Study

Stevenson (1993) reported that the compatibility of environmental education curriculum and environmental values that students develop after an environmental science course is still unanswered. He argues that the traditional environmental education emphasizes the factual or empirical questions about the environment and teachers often induce students to adopt ideas and behaviors held by external authorities. Stevenson suggests an alternative curriculum framework that emphasizes the need for students to actively construct environmental understanding and values. On the other hand, Robertson (1994) reported that a review of environmental education research literature reveals a paucity of constructivist-based research. If environmental education adopts a constructivist framework the learner's pre-instructional knowledge and the nature of learning and understanding would be emphasized. The present study provides the opportunity for adolescent students to construct their image of an environmental scientist with the hope that these perceptions can inform the development of appropriate curriculum and instructional methods and strategies in environmental science education.

This quantitative research was conducted to answer the following research questions.

1. What is the image of an environmental scientist as perceived by adolescent students?

2. Which seven indicators of the standard image of the scientist do students perceive with highest frequency for an environmental scientist?

3. What is the perception of adolescent students about the place and nature of study conducted by an environmental scientist?

4. What is the influence of students' prior knowledge and experience with their natural surroundings to their perceptions of an environmental scientist?

Findings from this study are important for curriculum developers, teachers, and institutions with science teacher preparation and enhancement programs. Information on students' perceptions of science and environmental scientists can guide in formulating educational goals and objectives, designing curriculum content and instructional practice to accommodate students' prior knowledge and personal experiences. The content standards of the *National Science Education Standards* (1996) include concepts about organisms and environment in grades K-4, populations and ecosystems and diversity and adaptation of organisms in grades 5-8, and interdependence of organisms and their environment in grades 9-12. Likewise, the *Benchmarks for Science Literacy* (1993), explains how the "sense of wonder at the rich diversity and complexity of life is easily fostered in children. They spontaneously respond to nature (p. 100)."The Living Environment" is included among the core of specific science literacy goals in the *Benchmarks* where the levels of understanding and ability that all students are expected to reach on the way to becoming scientifically literate about organisms, ecosystems and how they affect one another are gradually presented. Teachers realize the increasing complexity of these concepts beginning at the middle school. At this age, students' perceptions are critical to their cognitive development and learning. Both the *National Science Education Standards* (1996) and the *Benchmarks* (1993) emphasize that to teach science effectively the curriculum and methods of instruction should adapt and respond to the students' interests, strengths, experiences, and needs.

Methodology

Research Design

This study employs a survey design (Creswell, 1994) using a projective instrument adapted from the Draw a Scientist Test (Chambers, 1983) to collect the perceptions of adolescent students.

Subjects

Seven hundred fifty-seven junior high and high school students from eight rural schools in a southeastern state of the United States comprised the subjects in this study. The area's environment consists of pine trees, rivers and streams, lakes, and nearby coastline to the Gulf of Mexico. These trees and bodies of water often are located on or near school property. There were 382 junior high students (grades 7-8) in a 1:1 gender ratio. A total of 375 high school students (grades 10-12) made up this sample population. There were 196 females in this group. The overall gender ratio in both groups is 388:369 in favor of females. The researchers assumed that the stratified sample based on grade level would show a difference in the students' perceptions of an environmental scientist caused by the type of science courses they study. The 13 to 14-year-old junior high school students were enrolled in Integrated Science and the 16 to 18-year-old high school students were in Biology 1. Integrated Science in the junior high school is a general science course that introduces the various natural sciences. In high school, Biology 1 is taught as a specialized science with more complex concepts and involved investigations. Constructivist teaching is more likely to be used in Biology I rather than in the Integrated Science. Most of the junior high teachers have a general science preparation with less science content; on the other hand, the biology teachers generally have at least 36 credit hours in the discipline. In addition, the laboratory activities performed in the Integrated Science course are mostly textbook-based and highly teacher-directed. The Biology 1 laboratory activities generally use the guided inquiry approach. The researchers also decided to use these stratified groups of students to find out if age influence their perceptions of an environmental scientist.

It is important to note that the teachers of these students participated at a summer workshop prior to the academic year when the data for this study was collected. The workshop was about teaching wetland ecology using the constructivist perspective as an instructional model. The projective instrument, Draw an Environmental Scientist (DAEST) was administered to their students at the beginning of the 9-week block for environmental science unit. The intention of the researchers was to collect students' perceptions of an environmental scientist before they are introduced to the nature and processes of studying the environment like an environmental scientist does. During the 9-

week block for environmental science the teachers adapted and implemented the lessons and activities from the workshop.

Table 1.

Total number of subjects by grade level and gender

	Junior High (Grades 7-8)	High School (Grades 10-12)	Totals
Male	190	179	369
Female	192	196	388
Totals	382	375	757

Instrument Used

The instrument used in this study is based on Chambers' (1983) Draw-a Scientist Test (DAST), a projective instrument designed to reveal students' perceptions of a scientist at different ages. The test requires students to draw a scientist using stick figures and any other graphical rendition of their impressions. The DAST was adapted for this study where the students also drew stick figures of an environmental scientist. In addition, they were asked to describe the image and the activity of the environmental scientist depicted in their drawing. The researchers refer to the adapted instrument as Draw an Environmental Scientist (DAEST). The Draw a Scientist Test Checklist (DAST-C) developed by Finson et al. (1995) was adapted to design a scoring rubric. The seven standard images of a scientist identified by Chambers (1983) were adapted as the first section of the Draw an Environmental Scientist (DAEST) checklist shown in Figure 1. The second section of the DAEST checklist represents the alternative images of an environmental scientist. The alternative images in DAST-C (Finson et al., 1995) were included and the researchers added three indicators, namely: gender, ethnic origin, and age. The researchers considered these three indicators as alternative to the "white (Caucasian) elderly male in a white lab coat" image of a scientist. These indicators and specific descriptors were added in the DAEST checklist because they showed up frequently in the drawings of students during a pilot test. A third category, Additional Images of an Environmental Scientist, contains five indicators, namely, savior of the earth, work settings, nature of scientific work, type of scientist, and emotions of an environmental scientist. These additional images that are generally depicted in magazines, movies, and television programs were included in the instrument because they also showed up in the pilot study. Figure 1 presents the nineteen indicators subsumed in three categories of the Draw an Environmental Scientist (DAEST) Checklist.

STANDARD IMAGE:

1. Lab coat ________
2. Eyeglasses ________
3. Facial growth of hair ________
4. Symbols of research ________
5. Symbols of knowledge ________
6. Technology ________
7. Relevant captions ________

ALTERNATIVE IMAGES:

8. Gender: ________
    a. Male
    b. Female
    c. Gender neutral
9. Ethnic background: ________
    a. Caucasian
    b. African-American
    c. Asian
    d. Ethnic neutral
10. Age: ________
    a. Middle-aged
    b. Elderly scientist
11. Indications of danger ________
12. Presence of light bulbs ________
13. Mythic images ________
14. Indicators of secrecy ________

ADDITIONAL IMAGES OF AN ENVIRONMENTAL SCIENTIST:

15. Savior image ________
16. Natural setting(s) of work: ________
    a. Water environments
    b. Mountains
    c. Trees/forest
    d. Soil/dirt
    e. Wildlife
    f. Urban/city
17. Nature of scientific work: ________
    a. Observing
    b. Measuring
    c. Testing samples with scientific equipment
    d. Collecting data
    e. Experimenting
    f. Reporting
    g. Work cooperatively

____

18. Type of scientist:
    a. Wildlife biologist
    b. Aquatic scientists
    c. Forester
19. Emotions: _______
    a. Joy and hope
    b. Sadness

TOTAL SCORE: 19 _______
Score of:
  Standard images: 7
  Alternative images: 7
  Additional images: 5

Figure 1. The Draw an Environmental Scientist (DAEST) Checklist

Administration of the DAEST

Three hundred eighty-two students in grades 7-8 and 375 students in grades 10-12 were subjects in this study. They were instructed to draw their perception of an environmental scientist on a blank sheet of paper. On the back of the paper, they were asked to answer two questions: (1) Briefly describe the image of the environmental scientist you drew; and (2) What is the environmental scientist doing? These questions clarified ambiguities in their drawings. Students were instructed to write their gender and grade level on the upper right-hand corner of the drawing.

Analysis of Drawings

During the pilot study, three scorers analyzed the drawings of a comparable group of students using the Draw an Environmental Scientist-Checklist. An inter-scorer reliability of 0.95 was obtained using Cronbach's alpha. Each scorer used the DAEST-Checklist to analyze the drawings from the 757 subjects. Using Finson et al.'s (1995) scoring system, one mark was placed on each blank of the checklist if an indicator was present in the drawings or answers to the questions and later summed to find a score for each section. Although more than one descriptor might be present in a drawing, the maximum score on any single indicator is one. The indicator and descriptor frequencies were collected for the quantitative analysis of this study.

Findings and Discussion

The analyses of the drawings reveal that an environmental scientist is perceived by junior high school and high school students in this study as a mosaic of the standard image of a scientist and alternative images, and having additional characteristics specific to an environmental scientist.

The Standard Image of an Environmental Scientist

All seven indicators of the standard images of a scientist (Chambers, 1983) were present in the subjects' drawings of an environmental scientist. Table 2 shows the rank order and percent frequency of indicators of a standard image of an environmental scientist drawn by the subjects. The rank order of Chamber's list was used for comparison. The rank order of the first four indicators were similar to Chamber's list except the indicator "facial growth of hair" was ranked sixth by the junior high school students and fifth by the high school students. The investigators have no explanation for the low frequency of the indicator "facial growth of hair". Very few subjects mentioned "facial hair" in their descriptions. Similar to Chamber's list, the indicators for "technology", and "relevant captions" were ranked low by these subjects. The subjects' association of technology with computers, which are generally not seen outdoors, might explain this.

Table 2

Rank order of the indicators of the standard image of the environmental scientist as perceived by junior high and high school students

Rank Order of the Standard Image of a scientist (Chambers, 1983)	Junior High School Students' Standard Image of an Environmental Scientist		High School Students' Standard Image of an Environmental Scientist	
	Indicator rank	%	Indicator rank	%
1-lab coat	1	80	2	74
2-eyeglasses	3	72	1	77
3-facial growth of hair	6	44	5	60
4-symbols of research	4	70	3	73
5-symbols of knowledge	2	76	4	69
6-technology	7	5	6	10
7-relevant captions	5	54	7	9

The Alternative Images of an Environmental Scientist

When the drawings were analyzed for alternative images, it was interesting to observe the candor with which the subjects drew many alternative images of a scientist that helped define their perceptions of an environmental scientist.

Table 3 shows the percentage of indicators on the alternative images of an environmental scientist drawn by the subjects. Seven indicators assessed in this category are: (8) Gender, (9) Ethnic Background, (10) Age of Scientist, (11) Indications of Danger, (12) Presence of Light Bulbs, (13) Mythic Images, and (14) Indicators of Secrecy. Indicators 8, 9, and 10 were expanded to accommodate the specific characteristics (called descriptors) shown in the drawings of the subjects. Indicator 8, "Gender" was expanded to "male", "female", and "gender-neutral". Indicator 9, "Ethnic

Background" was expanded to accommodate drawings that depict, "Caucasian", "African-American", "Hispanic", "Asian", and "Ethnic-neutral". Indicator 10, "Age of scientist", two choices are included, "middle age" and "elderly" to accommodate the subjects' perceptions. Table 3 summarizes the responses to the indicators on the alternative images of an environmental scientist.

Table 3

Percent responses on the alternative images of an environmental scientist drawn by junior high and high school students.

Indicators	Descriptor of indicators	Percent of total response by junior high students	Percent of total response by high school students
8- Gender	Male	40	30
	Female	21	22
	Gender-neutral	39	48
9- Ethnic Background	Caucasian	90	76
	African-American	3	10
	Hispanic	1	4
	Asian	1	2
	Ethnic-neutral	5	8
10-Age of scientist	Middle age	80	75
	Elderly	20	25
11-Indications of Danger		0	0
12-Presence of Light Bulbs		0	0
13-Mythic Images		0	0
14-Indicators of Secrecy		0	0

On the indicator on gender, 21% of junior high school students and 22% of high school students revealed their awareness of female environmental scientists. It is notable that 11 percent of the drawings by junior high and high school students depicted a female environmental scientist. Here are two samples of responses from female students:

a) " I don' think there is a certain appearance for an environmental scientist. They can be a man
or a woman, white or black or Oriental, young or old. I think that they are environmentally

conscious and probably like the outdoors. May be I am wrong but I don't think they wear lab coats

all the time. I think much of their time outside collecting samples and observing."(sic), and

> b) "An environmental scientist is just a person. It can be either a man or a woman. He or she can dress the way she or he wants and can look like they want. Some might wear glasses, others might not—it depends on each's (sic) eyesight. Some might be messy and others nest. Environmentalists each have their own characteristics and personalities, just like other people. Environmental scientists are smart and interested in the environment.

Figures 2 and 3 are pictures of female environmental scientist drawn by female students.

Figure 2. Drawing of a female environmental scientist.

Figure 3. Drawing of a female environmental scientist.

The findings on gender and ethnicity of an environmental scientist underscore the importance of role models, both in person or as represented in textbooks, magazines, television programs. Role models impact the cognitive learning of all students including culturally diverse students (Barba, 1995). Perhaps, television presentations of Jane Goddall and other female wildlife biologists may have brought about awareness that there are female environmental scientists. Future studies might aim at further defining the determination of how students determine their gender notion of environmental scientists. The indicator on ethnic background also revealed that some students are aware of the diversity of persons who do environmental science study. Ninety percent of junior high school students and 76 percent of high school students perceived the environmental scientist to be Caucasian. However, the trend of ethnic awareness is emerging in the responses of the two groups. This awareness may be influenced by their social exposure to persons from different ethnic backgrounds through socializing agents such as church, community, peer group, sports, and media (Gage & Berliner, 1998). Another explanation for this awareness of ethnic diversity by high school students may be in the changes in perspective-taking that occur as students mature (Woolfolk, 1998). Also relevant to these findings are the higher than normal minority population in this area of the country; a few of them work in science-related industry as technicians. It is emphasized in this study that role models influence students' perception of the gender and ethnicity of an environmental scientist.

The middle age scientist was the popular image drawn by both groups. This finding may be explained by the fact that the age of the an environmental scientist is subconsciously coupled with outdoor activities such as hiking, collecting plant and animal specimens, and recording field data. Students' drawings showed this type of association in the type of clothes worn in their drawings. Twenty percent and 26% of the drawings by junior high and high school students, respectively, depicted an environmental scientist wearing jeans, overalls, and T-shirt. On the other hand, both groups of students ranked the indicator for "lab coat" as "1" and "2" for junior high and high school students, respectively, shown in Table 2. Despite the fact that environmental scientist is portrayed working in the river, or stream, a majority of the drawings showed them wearing a semblance of a lab coat. Certainly the association between scientists and their lab coats is a strong one. A few drawings show an environmental scientist working in the outdoor amidst trees and pond, yet he/she wears a lab coat and works on an improvised laboratory table in the outdoor or in a nearby laboratory in a makeshift room as shown in Figures 4 and 5. Surprisingly, that there were no drawings depicting indications of danger, presence of light bulbs, mythic images, and implications of secrecy.

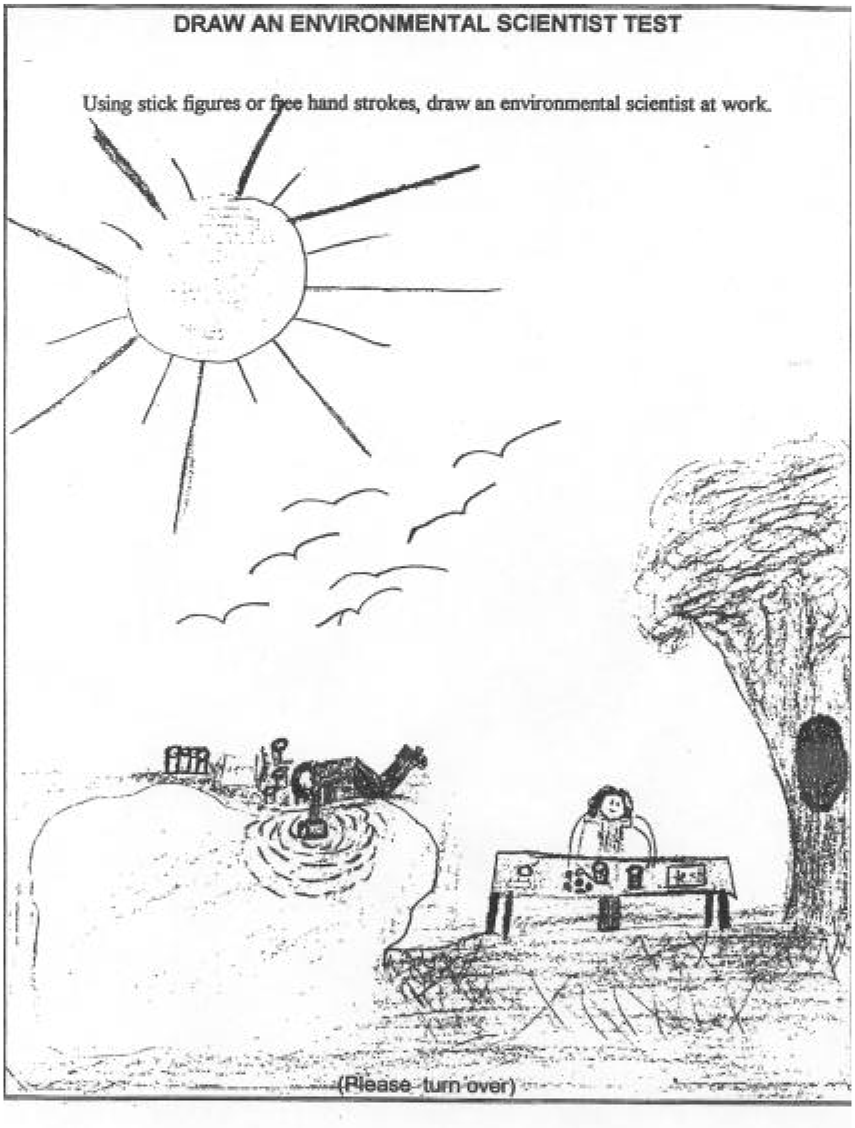

Figure 4. Sample drawing showing settings of work for an environmental scientist.

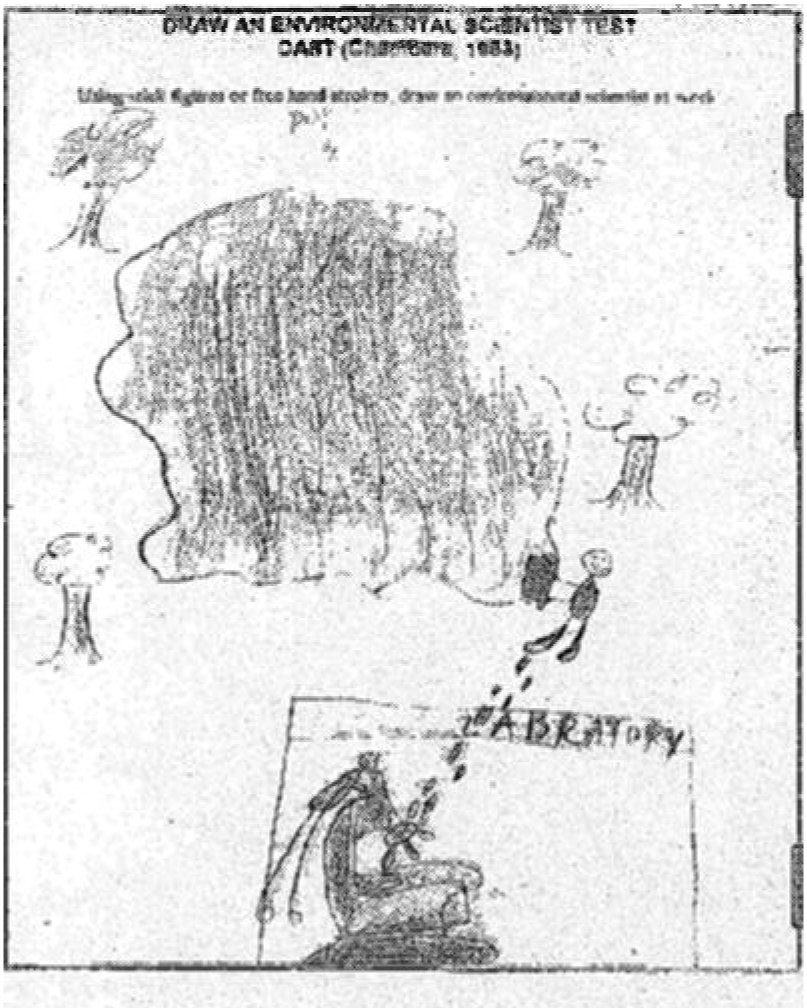

Figure 5. Sample drawing showing settings of work for an environmental scientist.

<u>Additional Images of an Environmental Scientist</u>

The additional images specific to an environmental scientist was depicted in the five indicators of the Draw an Environmental Scientist checklist. These indicators are: (15) Savior of the Earth, (16) Settings of Work, (17) Nature of Scientific Work, (18) Type of environmental scientist, and (19) Emotions of an environmental scientist. Indicator 16, the Settings of work, was expanded to include common environments in which environmental scientists perform their work. Indicator 17, the Nature of Scientific Work, was expanded to include science process skills. Indicator 18 defines the type of scientist such as aquatic scientist, forester, and wildlife biologists. Finally, Indicator 19 serves to record the emotions of joy, hope, and sadness of the environmental scientist drawn and described by the subjects. Table 4 summarizes the additional images of an environmental scientist analyzed from the drawings of the subjects.

Table 4

Percent of indicators on the additional images the environmental scientist drawn by junior high and high school students

Indicator	Descriptor of indicator	Percent of total response of junior high students	Percent of total response of high school students
15-Savior image		2	5
16-Settings of work	Water environment	63	30
	Mountains	21	12
	Trees/forest	77	69
	Soil/dirt	5	11
	Wildlife	73	78
	Urban/city	2	4
17-Nature of scientific work	Observing	37	29
	Measuring	18	25
	Testing samples with scientific instruments	15	33
	Collecting data	30	40
	Experimenting	4	15
	Reporting	0	2
	Working cooperatively	0	1
18-Type of scientist	Wildlife biologist	2	10
	Aquatic scientist	5	5
	Forester	10	7
	Generic drawing	83	78
19-Emotions depicted	Emotions of joy/hope	8	2
	Emotions of sadness	2	7
	No emotion depicted	90	91

Only 5% of high school students' and 2% of junior high students' drawings had captions that read, "Save our Planet," "Save the Trees," "Keep Our Environment Healthy, " suggesting that the environmental scientist was seen by some as the savior of an endangered environment. This finding is similar to what Chambers (1983) reported. The researchers considered this an important indication that often when students transferred emotions onto a drawing of an environmental scientist they were shown as a compassionate human being as opposed to the Dr. Jekyll and Mr. Hyde image of a sinister scientist. The researchers suspect that this perception may have been influenced by the media and school projects on recycling, tree planting, beach clean up and etc**.**

The most popular settings of work drawn by the subjects were the water environments such as rivers, streams, and wetlands surrounded by trees and vegetation. This might be explained by the familiarity of the subjects with rivers and streams traversing their school and the community where they live. Another popular natural setting drawn is the forest where wildlife abounds. Again, familiarity with the forest and the hunting activity most high school students engaged in could have influenced their perceptions. The researchers believe that the presence of the forest industry in their community and the popularity of hunting could explain the associations made by the students.

The most common perceptions about the nature of work by an environmental scientist drawn and expressed by the junior high school students were observing (37%) and collecting data (30%). On the other hand, high school students also drew and expressed environmental scientist collecting data (40%) with scientific equipment (33%), experimenting (15%) to find out sources of pollution, and writing observations (29%) about wildlife and water quality. Excerpts from answers of the subjects to the question on the activities conducted by an environmental scientist are: "They do stuff like taking soil samples", "...looking at rain clouds", "..find out what kinds of trees are growing in an area", "...test to find out if the rivers are polluted", "…to see if animals on earth are doing as they should", "...collect information to find out if the earth is clean, and lakes, and oceans, too."

Generally, the type of scientist drawn was generic; however, a small percentage of the pictures drawn depicted a wildlife biologist, a forester, or an aquatic scientist. Ten percent of the junior high school students and 7% drew a forester to depict an e environmental scientist. Five percent of drawings from both groups pictured an aquatic scientist. The reason for these drawings may be due to the association and immediacy of experience with persons in science-related occupations. The subjects reside in an area of the state where forest industry is the main economy. The county extension workers are mostly foresters and wildlife biologists; thus, this association may have influenced their responses. Ten percent of high school student drawings depict a wildlife biologist. Many of the male subjects in this age group hunt with relatives and/or friends and this might explain the association between environmental science and wildlife. This finding shows that association and personal experience of adolescent students with persons in science-related vocation and the exposure to phenomenon and issues affecting their immediate surroundings (e.g., water pollution) may be used to trigger environmental awareness.

The indicator for "Emotions" helps to assess the expressions depicted in the drawings. Eight percent of the drawings by junior high school students express joy and hope that environmental scientist will rescue the planet from destruction, whereas seven percent of high school students drew expressions of sadness and concern about the environment. High school students expressed sad emotions more than the junior high students did. Are some of the doom and gloom predictions influencing high schools students' perceptions? The researchers examined the biology curriculum content and concluded that the lessons and activities in the biology course influenced high school students. There were lessons on pollution, endangered species, and overpopulation. In addition, high school students were more often exposed to scientific reports and global environmental issues than junior high school students. The researchers also believe that high schools students are better able to relate their knowledge about ecosystems to local and global environmental issues. The issues most pertinent to these students are pollution of rivers, streams and the Gulf of Mexico, and endangered wildlife. Students' drawings portrayed factories discharging waste in the rivers as the culprit for river pollution. However, neither junior high and high school students did not associate endangered wildlife to the rampant tree cutting causing the lost of wildlife habitat. The industry in the communities where the subjects reside is forest and forests products where tree cutting is considered an acceptable tradeoff to economic livelihood. It is interesting to note that overpopulation and air pollution were not among the environmental concerns depicted in the drawings. In a study of freshman and sophomore engineering students in Krakow, Poland it was revealed that air quality ranks as the number one environmental concern (Robinson & Bowen, 2000). Comparing the perceptions of students from the rural communities in the United States and the students in an industrial city indicate that personal experience with the local environmental issues influence their perception of environmental threats.

Implications to Curriculum and Instruction in Environmental Education

The simple projective test used in this study provides convincing evidence that adolescents can construct meaning from what they know and what they experience. Thus, constructivism as a philosophy of learning that is based on the premise that students construct their own understanding of the world would be an appropriate framework to use in developing curriculum for environmental education. Several reports have provided support that constructivist framework has its place in environmental education.

Klein and Merritt (1994) identified four components of constructivism and studied sample lessons from four leading environmental education curriculum materials. They reported many parallels between the methods of environmental education and the components of constructivism. Both philosophies of education require that students take an active role in learning, to learn beyond factual knowledge, and provide an opportunity to improve investigation and critical thinking skills. Munson (1994) warned that the existence of ecological misconceptions poses a serious problem for environmental educators in developing appropriate curriculum materials. After identifying 5 basic ecological principles and students' pattern of misconceptions on these principles he advised against filling the void of knowledge for the students. Instead, students should be presented with experiences that encourage them to learn conceptually by abandoning their misconceptions in favor of scientifically acceptable conceptions (Hewson & Hewson, 1988 in Munson, 1994). According to Munson using the knowledge on misconceptions and developing curriculum and instructional strategies based on the constructivist perspective would help students gain meaningful knowledge of ecological concepts that they should be able to use and apply in making decisions on important environmental issues.

What constructivist-based curricula and teaching strategies provide meaningful learning to students? Klein & Merritt (1994) studied the following environmental education materials and concluded that they exemplify constructivism: *Project Wild, Project Learning Tree, Aquatic Project Wild, Great Explorations in Mathematics and Science (GEMS), Save Our Streams Teacher's Manual, and Ranger Rick's Naturescope*. These constructivist-based environmental education materials consider that students have prior knowledge and experiences that help "construct meanings by forming connections between new concepts and those that are part of an existing framework of prior knowledge." (Mintzes, Wandersee, & Novak, 1998, p.47). Glasersfeld, one of the leading constructivist philosophers, recognizes the role of a teacher and the importance of a teacher's own knowledge in influencing student learning. He stresses that "knowledge cannot simply be transferred" through linguistic communication and that teachers must understand the way their students view the world. In addition, he assigns substantial importance to the role of social interaction (as in cooperative learning) in the construction of personal knowledge and the role of such interactions in the way we synthesize much of what we know about the world (Mintzes, et al., 1998, p.45).

The findings of this study provide evidence on adolescent students' ability to construct knowledge about an environmental scientist and the work that he/she does. Students in this study reveal their concept of an environmental scientist to be a human being that possesses characteristics such as gender, ethnicity, age, interest in their work, and emotions about the environment. This finding could be used to build a humanistic constructivist environmental education curriculum. The present concern for environmental problems extends the boundaries of environmental education from local to global. The principle of ecological interconnectedness and interdependence would be a powerful theme to build on. The human constructivist approach proposed by Novak could be implemented in environmental education using integration as a curriculum design. Beane (1997) described the features of curriculum integration that distinguishes it from other approaches, as follows:

> First, the curriculum is organized around problems and issues that are of personal and social significance in the real world. Second, learning experiences in relation to the organizing center are planned so as to integrate knowledge in the context of the organizing centers (themes, supplied by authors). Third, knowledge is developed and used to address the organizing center (theme) currently under study rather than to prepare for some later test or grade level. Finally, emphasis is placed on substantive projects and other activities that involve real application of knowledge, thus increasing

the possibility for young people to integrate curriculum experiences into their schemes of
meaning *and* to experience the democratic process of problem solving (page 9).

Instructional interventions using the constructivist perspective to clarify students' view of science, the scientist, and the activities in science have reported success stories. These interventions could be adapted to develop a humanistic constructivist environmental education curriculum. One intervention is the use of inquiry activities using the scientific processes to help students clarify their view of scientist and science (Mason, Kahle, & Gardner, 1991). In another study, Damnajanovic & Kahle (1993) reported by sex and race the positive effect of inquiry activities on elementary students' enjoyment, stereotypic perceptions, self-confidence, and ease of doing science. Another form of intervention is the "Scientist-in-residence" program conducted by Flick (1990). His study proved the effectiveness of a professional scientist who regularly teaches with the teacher in elementary and middle schools in helping students understand that science is performed by ordinary human beings using a process unique to the nature of scientific investigations. Owens (1998) studied the effect of instruction by a professional scientist on the acquisition of integrated process skills and science-related attitudes of eighth grade students. She found significant difference in the science-related attitudes and the acquisition of science integrated process skills between students taught by a professional scientist and a professional educator favoring the group taught by the professional scientist. Students also reported that the professional scientist clarified the problem-solving work that scientist does. Owens (1998) also reported that the images of a scientist drawn by the students taught by a professional scientist showed a remarkable decrease in the stereotypic images in the posttest when compared to the images drawn during the pretest.

Multicultural science lessons are another form of intervention. Programs involving scientists similar to those earlier described might change the stereotypic image of scientists among young students. Teaching science lessons about specific individuals, especially women and minorities, who have made contributions in science also gives students a meaningful reference and a powerful role model (Porta, 2002). On the other hand, prior knowledge has a cultural aspect. This aspect includes the kind of knowledge that learners acquire because of their social roles, such as those connected with race, class, gender, and their culture and ethnic affiliations. This cultural knowledge can sometimes support and sometimes conflict with children's learning in schools (Greenfield and Suzuki, 1998 in Bransford, 2002). The meanings that are attached to cultural knowledge are important in promoting transfer—that is, in encouraging people to use what they have learned (Bransford, 2002). The reality of diverse learners in many classrooms across the country presents a challenge to curriculum developers in environmental education. Nature or the environment is regarded differently by different groups of people. Some ethnic groups regard the environment with awe and reverence, other groups recognize the environment for its utilitarian value, and still others espouse the principle of coexistence with nature.

Individual students construct knowledge about science within a sociocultural context similar to their pattern of socialization in extended family systems or familiar learning environments. Vygotsky's sociocultural theory of learning offers support to the findings in this study. The sociocultural theory of learning states that children are socialized into learning using the appropriate cognitive and communicative tools that have been passed down from generation to generation. Through such socialization, children learn the accumulated ways of thinking and doing that are relevant to their culture(s). An aspect of Vygotsky sociocultural theory is scaffolding that refers to the supports for learning, such as working cooperatively with peers, coaching by teacher, or other learning tools. When learning skills, interactions with a more advanced partner or an adult are more effective. However, learning to consider another perspective is more effective with children's peers because there tends to be a free and active exchange of ideas may provide for a more open forum for discussing issues. Environmental issues are better discussed in cooperative learning groups than in teacher-student interaction.

Field trips and field study are interventions that have received much acclaim. Hale (1986) asserted that successful environmental education occurs when field studies are based in the school grounds or local environment. This coincides with the perspective and effective pedagogy of a constructivist-based environmental education in an integrated curriculum design. This study confirms the belief that children are interested in their surroundings. This assertion is documented by the way students express their perception of environmental scientists and the work they do in the environment. It becomes imperative in a constructivist framework to capitalize on students' existing knowledge and perceptions to infuse environmental education. The benefits include a more environmental stewardship and knowledge toward the environment (Gifford, Hay, & Boros, 1982; Jaus, 1984; Thomas, 1996). Field studies by their inherent, encompassing nature necessitate integrating the curriculum and allow students to incorporate multiple intelligences and personal perceptions into their work. The results of field studies conducted in this manner comply with the national and state science standards to produce a functionally literate body of citizens that understand and participate in the science around them. Environmental studies that are constructivist-based that aim to develop environmental, knowledge, awareness and attitudes should be (1) content appropriate for the student learning level, (2) require students to solve a local problem from their own perspective, and (3) infuse a moral decision(s) by creating conflict in a students' schemata. Their moral decision may understandably require a student to consider tradeoffs between positive and negative aspects learned from their environmental study.

Future Research and Recommendations

This study indicates that adolescents are strongly influenced by their experiences with the natural environment gained from activities they do outside of the school curriculum. In other words, their knowledge of the environment may be developed through informal methods. The study also provided information on how the various influences on students' perceptions can be explored to understand stewardship could be integrated in environmental education curriculum.

The researchers realize that it is very important to collect the prior knowledge and experiences of students with the environment. Two methods to collect this information may be used, such as the free association test and the focus group interview. Schaefer (1980) described the free association test where students are asked to write words and/or phrases that come to their mind when a stimulus word (e.g., environment) is stated. The students are given time to respond. These free associations are then classified into categories that may reveal prior knowledge or positive or negative experience of a student on a concept. On the other hand, the focus group interview is a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, unthreatening environment (Krueger, 1994). During this interview corroboration of drawings and responses to interview could strengthen interpretations made by researchers.

After the logistic arrangement of concentrating the second nine-week block of the semester for the environmental science segment in the integrated science and the biology I curriculum, it would have been advantageous that a pretest-posttest research design was used. The researchers believe that nine weeks would be enough time for intervention.

Another area worthy of exploration is linking the theory of multiple intelligences to environmental education to discover and engage each student's talents. The various natural settings and activities in environmental education may nurture the development of students' interests.

Finally, classroom observation data on content of instruction and practices would provide significant information on their influence on students' perception of an environmental scientist. Implementation of constructivist teaching practices used by teachers could be examined if they influence students' perception of environmental scientists and the type of scientific investigation they conduct. In a similar light, curriculum integration as described by Beane (1997) applied in the environmental study segment of the Integrated Science or Biology I curricula could be applied and examined.

Conclusions

This study started as a survey of adolescent students' perceptions of an environmental scientist and the work or study he/she does. Using a simple projective test, a wealth of information used to construct the image of an environmental scientist emerged. In summary, adolescent students from the rural southeastern region of the United States perceived an environmental scientist as a mosaic figure showing the standard stereotypic image of a scientist, with new emerging alternative images, and having additional characteristics specific for the kind of work that environmental scientist does. It is interesting to note that the image of an environmental scientist drawn by the adolescent students presents similar rank order as those established by Chambers, except for the "facial growth of hair". Three new images such as, gender, ethnicity, and age emerged in their drawings. These emerging perceptions are contradictory to the stereotype of a "bald, old, white male scientist". In spite of the low percentages on indicators on "ethnicity" and "gender", the researchers consider this observation worthwhile to record and sources of their perceptions may be an interesting follow-up study in the future. The additional images of an environmental scientist define the setting, type and nature of work and emotions that student may vicariously feel with the environmental scientist about the condition of the environment. In summary, the pictures drawn present the adolescents' human view of an environmental scientist.

After careful analysis of the drawings and the brief descriptions, the researchers concluded that adolescent students constructed their perceptions based on prior knowledge and personal experiences in their natural environment and the persons who perform science-related vocation became their model of an environmental scientist. Based on these responses the researchers are convinced that the students apply the primary tenets of constructivist pedagogy, i.e., using prior knowledge to construct meaning of new experiences. In addition, the findings of this study reinforces Ausubel's profound statement about learning and the learner, which states, " The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly"(1978, p.160, in Driscoll, 2000).

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