Understanding the Nature of Science: Science Views from a Seventh Grade Classroom

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CHAPTER 5

Understanding the Nature of Science: Science Views from a Seventh Grade Classroom

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ABSTRACT

This research study was done in collaboration with the Science Education Partnership and Assessment Laboratory (SEPAL). We attempt to elucidate a seventh grade students’ understandings and views of science. This research was performed in the context of a single classroom encompassing 96 seventh grade students at an urban public middle school in San Francisco, CA. This analysis contributes further insight into students’ science views through the use of open-ended surveys and video interviews to better understand students’ science views. To date, no study have been conducted, focusing on the religious, cultural and self-identified views of an urban American middle school student population.

Based on written responses and interviews from our participant population we believe students science views are similar for secondary science students and adults, indicating that their beliefs are enforced early in their development.
INTRODUCTION

Since the early 1960’s, major efforts have been undertaken to enhance K-12 students and science teachers' NOS (Nature Of Science) views (Lederman et al, 2002). NOS refer to the epistemology and sociology of science, science as a way of knowing, or the values and belief inherent to scientific knowledge and its development (Lederman, 1992). Scientists and educators alike agree that students should develop an informed view of the NOS (American Association for the Advancement of Science, 1989, 1993, Bell, 2003, California State Board of Education 1998, Lederman et al 2002, 2001, National Research Council, 1996). While philosophers, historians and sociologists disagree on specific issues of NOS, there are accepted general characterizations. A major goal of NOS is to illustrate that 1) science is a tentative and dynamic process, 2) science is theory-laden, 3) science is the product of human inference, creativity and imagination and 4) much of scientific knowledge is heavily embedded in the culture and society we live in (Lederman, 2002)

One goal of our study was to explore specific aspects of seventh grade students' NOS views. While there is extensive literature on NOS Views (Abell et al, 2001; Adams, 2004; Bell & Lederman, 2003; Craven III et al, 2002; Dhingra, 2003; Lederman, 1992; Lederman et al, 2001, 2002; Schwartz at al.
to what extent do students understand the nature of science?
• To what extent do the students see the importance of human imagination and creativity in the scientific process?
• How do students culture, religion and ethnicity influence their scientific beliefs?
• To what extent do the students identify themselves as part of the scientific world?
METHODS

We performed this research in the context of three seventh grade classes taught by the same teacher. The total student population consisted of 96 seventh grade students at an urban public middle school in San Francisco, CA. 74 of the 96 students were participants in our study. The researchers knew all student participants, as the primary researcher (Jamie Chan) co-teaches in all three science classes through the National Science Foundation funded San Francisco State University GK-12 Partnership Program. Through the GK-12 Partnership Program, Jamie co-planned and co-taught inquiry based life science lessons to these students twice per week throughout the 2005-2006 school year.

In general, science education researchers have emphasized the use of multiple methods, including open-ended surveys and interviews, to better understand students’ science views (Driver, 1985 & 1993, Lederman et al, 2002, Schwartz et al, 2004). We have modeled our methods after a study that Lederman et al performed in 2002 using a questionnaire in conjunction with individual interviews.

Phase I: Ideas About Science Survey

To determine where students’ views were most divergent, a Likert scale survey addressing 12 aspects of the NOS and science views, called the Ideas
About Science Survey, was administered to all participants during a single class period in March 2006 (Figure 1). At this time demographic information (age, gender and date of birth) was also collected. Survey questions were validated through piloting with other research group members and asking seventh grade students their understanding of the meaning of the questions. The results of this survey allowed us to assess the scope of the students views and to help form what questions to explore further with students.

**Phase II: Toward a qualitative understanding of students’ science views**

To collect more narrative data on each students science opinions, a subset of questions from the Ideas About Science Survey were administered (Figure 2). These Science Reflections consisted of a Likert opinion scale and a short answer section which asked students to explain their Likert response. A total of seven Science Reflections were administered over a period of two weeks. The Science Reflections addressed four distinct NOS concepts followed by three questions about beliefs and self-identification with science. Students were administered one Science Reflection question per class meeting. An example of a Science Reflection can be found in Figure 3. Science Reflections were administered by Jamie Chan during a routine 30-minute assessment activity that occurred on days she was co-teaching in the classroom. The assessment activities called “Do Nows” consisted of a Likert opinion scale accompanied with
a short answer question about the current science content. These assessments are nearly identical in structure and length to the Science Reflections. Students completed these Science Reflections during a one week period in March 2006.

**Phase III: Individual Student Interviews**

Based on the Likert and written responses of the Science Reflections, 14 students were selected to participate in more extensive semi-structured interviews. We chose to interview a subset of students that displayed a range of articulate responses on the Science Reflections (Figure 4, Video). Interviewing 14 students, we sampled approximately 20% of the consented population of students. Interviews were done individually in either the library or a conference room at the middle school. Interviews ran for a duration of 10-20 minutes depending on the interviewee. All interviews were conducted by Jamie Chan.

During the interview, each student was asked to respond to a subset of the Phase II Science Reflection questions (Figure 5). Follow up questions were be used to elucidate ambiguities, assess meanings and explore the subject’s line of thinking (Figure 5). The interviews were digitally videotaped. This data was used to review responses as well as observe behavior and attitudes of subjects during the interview. Collier and Collier (1986) believe visual images capture the context as well as the actions of an event; they can be interpreted by multiple viewers; and the eye of the camera often freezes moments the human eye
ignores. All the interviewees were assigned pseudonyms and their self-reported
gender, ethnicity and religious affiliation were recorded at this time, see Table 1.
Student interviews were completed during a three week period in May 2006.

The San Francisco State University Office for the Protection of Human
and Animal Subjects granted approval for this study on March 9th 2006. 77 out of
96 seventh grade students assented to being in our study. 74 returned parental
consent to participate. Data for only the 74 students are presented here.

RESULTS

This study of 74 students yielded a rich data set. Since this is an action
research study, we present here the initial analysis of Phase II and Phase III
results. Based on the Science Reflection data, we observed the most articulate
and divergent responses centered around three major themes:

1) Students religious and cultural beliefs influencing their science views.

2) The role of imagination and creativity in science.

3) Students self-identification with science and scientific careers
Phase II Results – Science Views from a large cohort of 7th grade students

Science Views and Religion

Students were asked to respond to the following statement, “I feel that my family’s religion disagrees with the science I learn in school”. Survey responses from seventh grade students (n=68) reflected a majority of ambivalence about the religion statement see Table 2. 44% of the population rated the statement as a 3/Neither Agree or Disagree, with the second largest population (42%) rating the statement 4/Disagree or 5/Strongly Disagree. Only ten students selected a Likert score of 2/Agree or 1/Strongly Agree with the religion statement (14%). The distribution for this question (Figure 6) is similar to the distribution data collected in the Ideas About Science Survey (n=74).

Imagination and Creativity in Science

Students were asked to respond to the statement, “Scientists use imagination and creativity in their work”. Likert surveys of the complete student population (n= 69) indicated 50% reported a 2/Agree or 1/Strongly Agree (Table 3). 34% of the population rated the statement as a 3/Neither Agree or Disagree. And 10 out of 69 students selected a Likert of either 4/Disagree or 5/strongly disagree with the imagination & creativity statement (16%). The distribution for this question (Figure 7) is similar to the distribution data collected in the Ideas About Science Survey (n=74).
Self-Identification With Science

A two part statement was addressed the student’s self-perception as a member of the scientific world. The Likert rated statement was “I consider myself a science person” and the short answer statement read “Agree or disagree “Anyone can be a scientist”. Likert surveys of the complete student population (n= 68) reflected a large population of agreement with the science person statement see Table 4. 69% of the population rated the statement as a 2/Agree or 1/Strongly Agree, with the second largest population (21%) rating the statement with a 3/Neither Agree or Disagree. Only seven students (10%) selected a response of 4/Disagree of 5/Strongly Disagree with the science person statement. The distribution for this question (Figure 8) is similar to the distribution data collected in the Ideas About Science Survey (n=74).

Phase III – Views and opinions from Selected Students

Students struggle with religion and science views

Students were asked to respond to the following statement, “I feel that my family’s religion disagrees with the science I learn in school”.

Science Reflection Likert surveys of the 14 selected students reflected a large disagreement with the religion statement. Of the 14 selected students, 7 (50%) rated the statement as a 4/disagree or 5/Strongly Disagree. Four of the 14 (29%) rated the statement
with a 3/Neither Agree or Disagree and three individuals (21%) rated a 2/Agree or 1/Strongly Agree, (Table 2).

There were identifiable trends in the written reflections from the subset of students we reviewed. Students who rated the religion statement with a 1/Strongly Agree or 2/Agree would articulate contradictions between their religious beliefs and the science content learned in their classroom.

“Scientists think that you cannot come back alive when you die. My parents tell me earth and life is created by God. But scientists believe it is evolution. It (science) does interfere, I don’t know who to trust.”

- Tom

“…I don’t know how people came on earth and how we multiplied. The scientists says that we came from monkeys or they are our ancestors. I don’t believe that, I just believe that God brought us to this world…”

- Daniel

All these student responses reflected a sense of conflict between the evidence being presented in the science classroom and the evidence or lack of evidence presented to them in their religious practices. A subset of students
(n=2) who rated the Science Reflection religion statement with a 3/Neither Agree or Disagree, elaborated on the significance of evidence in scientific knowledge.

“We believe that evolution did occur but we also believe that God is the almighty and created life…I am leaning more on the side of science because there has been proof of relationships with humans and monkeys that evolution occurred, but there is no proof that God created humans.”

- Nancy

Another group of students (n=2) who rated the religion statement with a 3/Neither Agree or Disagree, found no connection between the science content taught in school and their religious beliefs.

“…we don’t put our personal beliefs with what I learn in science.”

- Renee

“We learn and go to school to succeed not to change religions or agree or disagree with something we’re learning.”

- Sarina
There were five subjects that had a Likert score of 4/disagree or 5/Strongly Disagree and reported their families values and beliefs were not in conflict with the science they learn in school.

“…my family feels comfortable letting me learn about science.”
- Dora

“….because my family always says science is the way to a new life.”
- Jane

For the students, science is considered a necessary skill, but it does not influence their personal beliefs. Again, similar to the population that chose a Likert score of 3/Neither Agree or Disagree, these students did not see the world of science as having any relationship with their personal beliefs or worldviews.

*Imagination and Creativity play specific roles in science*

Students were asked to respond to the statement, “Scientists use imagination and creativity in their work”. Based on written responses, 8 of 14 students (57%) of students rated the statement as a 2/Agree or 1/Strongly Agree with the second largest population, 4 of 14 (29%) rating the statement with a
3/Neither Agree or Disagree (Table 3). Two (14%) of the selected students responded with a 4/Disagree or 5/Strongly Disagree.

9 of the 14 students (64%) believed that imagination and creativity played a specific role in the scientific process. Two students reported that imagination and creativity were integral for generating scientific models.

“…if they (scientists) need something and they can’t get it they can create something shaped exactly like it so they can show them…”

- Aadam

Seven students out of 14 (50%) agreed that imagination and creativity occurs in during conjecturing and hypothesizing, before the experimental procedures and conclusions are employed.

“I believe that scientists use creativity and imagination in their work to help come up with their ideas. Then when they come up with an idea they can begin to prove it and support it with evidence.”

- Nancy
Two students were unsure about the role of creativity and imagination in science. Another two students strongly disagreed with the statement and believe that the use of creativity and imagination could lead to erroneous scientific work.

“If scientists use imagination then none of the things they tell us would be true. We would not know anything about science.”

- Renee

For a majority of the students, imagination and creativity is not considered a scientific tool for all aspects of science. Even though 57% of students rated the imagination and creativity statement as a 2/Agree or 1/Strongly Agree, they did not believe that it was an influential aspect of scientific discoveries and knowledge.

Self-Identification With Science

A two part statement was addressed the student’s self-perception as a member of the scientific world. The statement was “I consider myself a science person” and the short answer statement read “Agree or disagree Anyone can be a scientist”. Only 13 of the 14 selected students completed the written Science Reflection for this question. 76% of the 13 students rated the statement as a 2/Agree or 1/Strongly agree with the second largest population, (24%) rating the
statement with a 3/Neither Agree or Disagree (Table 4). Again, none of the students responded with a 4/Disagree or 5/Strongly Disagree.

There were several distinctive viewpoints among the selected students. One subset (n= 3), believed that academic success equates to the person’s achievement in scientific advancement. Within this subset two students also related the scientific profession with an elite form of financial success.

“I don’t think that anyone can be a scientist. They need good grades and need to know about science”.

- Tom

“I disagree with the statement that anyone can be a scientist. If it were true, everyone who wanted to be one would be one. Then everyone would have high paying jobs.”

- Lindsay

Two students emphasize a particular habit of mind that leads to success in the scientific field. There is less emphasis on the intellectual success of the individual and more about creative thinking.

“It doesn’t take a genius to be a scientist”.
“…being a scientists doesn’t have to be that you’re smart, it has to do with your ability to think creatively and to learn science.”  
- Jane

Four of the selected students believed that anyone could become as scientist as long as there was a genuine determination for success.

“Just as long as you gain enough knowledge into what it is about, and you’re passionate about being what you want to be. Anyone can be a scientist…”  
- Ava

Even though 76% of the 13 students rated the “I consider myself a science person” statement as a 2/Agree or 1/Strongly agree, most of the students interviewed had no desire to become a professional scientist and instead cited certain aspects of science they enjoyed. Ultimately, the students did not believe that anyone could be a scientist due to academic demands and social sacrifices that the individual would have to make to be a “successful scientist”.
**Student Interviews – Correlations and divergence from Science Reflections**

A majority of the 14 student interview responses matched their corresponding written Science Reflections. There were no direct contradictions in what they said and wrote.

Many interviewed students feel religion and science are not related

Six of 14 (42%) students who reported a 4/Disagree or 5/Strongly Disagree on their written religion Science Reflections felt that fundamentally, science and religion are separate entities that bear no relationship to one another. Five of the 14 (36%) felt conflicted by their religious views and the science they were learning in science class. Two of these five students rated a 2/Agree on the religion Science Reflection, another two rated a 3/Neither Agree or Disagree and the final student rated a 4/Agree. The remaining 3 students (22%) saw no conflicts (n=2) or had no reported religious affiliation (n=1). See Figure 4 Video.

Imagination and creativity have specific roles in science

The written Science Reflections for the imagination/creativity question and the student interviews correlate well. As stated previously, the imagination and creativity Science Reflection written response showed 8 of 14 students (57%) of students has a Likert rating of 2/Agree or 1/Strongly Agree. But most often the
role of imagination and creativity was specific to a particular aspect of the science process. We observed that a nearly identical sub-population, 9 of the 14 interviewed students (62%) believed that imagination and creativity occurs during conjecturing and hypothesizing, before the experimental procedures and conclusions are employed. Two of the 14 interviewed students (4%) believed imagination and creativity had no use in science and two students felt imagination and creativity could be used at all points in scientific research (4%). See Figure 4 Video.

Everyone is a science person but few want to be scientists

It was interesting to note that while 76% of the selected students rated the reflection “I consider myself a science person.” as a 2/Agree or 1/Strongly agree only 2 of 14 (15%) of interviewed students reported having any desire to pursue a career in science. A majority of the students found that they liked certain aspects of science but did not intend to become a scientist. The two students who wanted to pursue careers in science, did not directly attribute their experiences in the science class for their decision. See Figure 4 Video.

DISCUSSION

We present a mixed method investigation of middle school students. While there have been extensive studies on older populations this is the first
study of it’s kind, to focus on this under studied age group. Previous investigation of middle school students has provided conflicting opinions about student’s abilities to possess informed NOS views. A study performed by Kang et al (2004) on Korean middle school students concluded that there are no clear differences among 6th, 8th and 10th graders’ perspectives about the NOS. They found that the science experiences at the secondary level can exert little influence on the development of students’ views and merely support and maintain students’ naïve views during their school years. Contrary to this, a study performed on gifted Taiwanese seventh graders (Liu and Lederman, 2002) indicated the majority of participants had a basic understanding of the tentative, subjective, subjective, empirical and socially and culturally embedded aspects of NOS.

Based on written responses and interviews from our participant population we believe that science views are similar for secondary science students and adults, indicating that their beliefs are enforced early in their development. The science content and their religious and cultural beliefs are playing a role in the further maturation of their science views. A majority of the students showed aspects that aligned with contemporary scientific epistemologies. Not any one student was able to communicate fully informed NOS views. But current literature suggests that students from various age groups, and even teachers, possess both inaccurate and inappropriate views of the NOS (Lederman, 1992).
Science and religion views develop at an early age

Authors on the views of the science and religion (Barbour, 1997; Haught, 1995; McGrath, 1999) have several developed distinct categories for thinkers in respect to religious beliefs in science. We have considered the 14 Phase III students’ responses in three of these categories:

Distinct Students – Students who are distinct believe that the natural sciences have no bearing on religious affairs. They believe that science operates in one sphere and religion in another. Approximately 58% (n=8) of our Phase II student population fall into the category of distinct student thinkers. Many saw little to no connection to the science content they learned in school and the religious and cultural beliefs they practiced at home. This is nearly identical to the viewpoints observed in a recent study of college level science students (Shipman et al. 2002). In this study of 84 college astronomy students, 49% displayed a distinct view of religion and science.

Convergent students tend to take a more integrated approach to understanding the relationships between science and religion. 14% (n=2) of our Phase II population fell into this category. Although a majority of the students were “struggling convergent thinkers” in that they still had many internal conflicts
about how science and religion can be understood from a holistic approach. Many of the students arguments centered around evolution and origin theories that they were learning in class this year.

“…..there’s one thing about, it doesn’t say in the bible, that dinosaurs exist so I didn’t really get if dinosaurs existed or not, so I didn’t really know.”

- Daniel

Transitional thinkers are individuals who put considerable thought into religion and science and make observations about the characteristics that both separate and unite religion and science. Two students (14%) were identified as transitional thinkers. An example of a transitional response would be from Jason’s interview in which he states:

“…there are two different stories, I mean, we learn about cells and how they reproduce and how they got on earth. But there are two stories to that. Here we have a scientific story, where, somehow, life formed on earth a billion years ago and then you have the story of Adam and Eve, where God created Adam and Eve from clay….both of these stories have some beliefs and then again they have things that can possibly happen.”

- Jason
He can clearly see that there are belief systems present in both science and religion. His opinion is that both these elements exist due to the presence of strong beliefs and evidence in both spheres.

The last population (n=2) in the Phase II group were clearly undecided about what their opinions on science and religion were. Both of the interview participants admitted to having no strong religious affiliations and cultural influences (14%).

The observed similarities to the thinking styles of our Phase II population lead us to believe that students beliefs and NOS views on religion and culture are being developed at a young age and maintained into adulthood. This further strengthens the beliefs that a developing epistemology likely exists at a younger age (Montgomery, 1992; Wellman, 1990).

*Imagination and creativity are not viewed as holistic tools of science*

While many experts agree that even college students and teachers have a hard time understanding the role of creativity and imagination in science. Our study suggests that these deep seeded misconceptions are starting at a very early age and perpetuating into their adult lives. Only two of the 14 interviewed Phase II students saw imagination and creativity as an important tool in science. One of these students Sarina, describes how imagination and creativity contributes to the proliferation of more scientific discoveries.
“I mean once they find something…like germs. They keep coming up with more and more stuff to try to find the exact thing. Just like when you’re finding a formula when you’re cooking, you one thing and (think) Oh! It tastes good with this! What else can I put? I think they (scientists) have no end in their work…”

Sarina

_A generation of science people but no scientists…_

It is an unfortunate, but true observation that most of the students who completed interviews and students’ written Science Reflections forecast a future generation of people who do not have a personal investment in science. While we feel that the students have a positive view of scientific discoveries and the doing science in the classroom, they do not feel immersed in the world of science. The culture of science, at least what is known to them as seventh grade students, seems unappealing life goal. Whether this impression is made by popular culture, religious beliefs, familial standards or the science classroom itself remains to be determined. But it is clear to us that these students are currently struggling to make decisions about their participation in the scientific world. We believe that this lack of recruitment into science will not be due to a lack of interest or ability to develop informed NOS views. One student Tom, states that he once believed he would be a scientist, but the current educational environment leads him to believe that he cannot succeed in science.
“Well, when I was little, I was really, really, into science. Like, I participated in all
science projects and stuff. But, I can’t say I got all A’s on them, but yeah, I was
doing pretty good in science when I was little. I was like, doing projects and
learning stuff from other friends. Looking at their projects and seeing how stuff
works. I think when I was little people taught me a lot because, they taught me
how a light bulb works and how electricity flows through it…Right now (in seventh
grade), it’s pretty good. But basically it’s books, and books, and more books, you
have to read, but when I was little you can actually test things out. Like I got to
make my own fan and make my own light bulb work and yeah. I think science to
me, was way more important when I was in elementary school, because right
now, we have to work on every single subject and it’s kinda hard to focus only on
science…” -Tom

**Understanding seventh grade NOS views and self-identifications with science**

Contrary to previous studies, our seventh grade students show a diverse
range of opinions and NOS views. We believe that secondary science
experiences are influencing the development of seventh grade student’s NOS
views, and self-identification with science. It is at this time in their education,
when students are being taught controversial science subjects such as
evolution, origin theories and genetic engineering in the classroom. These
subjects have prompted our students to re-evaluate their understanding and identifications with science. It has been found that student views of science or epistemological beliefs are significantly related to their knowledge integration and learning orientation methods (Songer and Lin, 1991; Tsai, 1998). We believe the this study contributes to further understanding the scope of adolescents science views. While this study was not designed to measure collect a pre and post set of data, we noticed a slight shift from the Ideas About Science Survey to the Phase I Science Reflections. The students showed more informed NOS views. This shift may be due to the addition of a written reflective component of the Phase II questions, which could have elicited a more meaningful response than a Likert score.

The wonderings of a research scientist and future directions

This study was performed due to the primary author’s desire to understand her students science views better. Being in the NSF GK-12 partnership program and working in several diverse urban classrooms had interested her in the way that students were perceiving the science they learn in school and how it may affect their eventual career goals. She saw that many students had a genuine enthusiasm for the hands-on, inquiry based lessons, but many would say that they did not “succeed” in science because it was too “hard”. This gap between the joy of doing science activities and the lack of desire to
succeed in higher science education was a compelling mystery to her. It was her purpose to probe the student’s NOS views and self-identifications with science.

Due to the great amount of qualitative data collected, a more systematic analysis of the written Science Reflections is necessary. Also, individual interviews with more students would provide deeper understandings of the scope of seventh grade students science and NOS views. Performing the study in the context of a whole school year would provide more insight to the influence of the specific science content being taught to the students.
LITERATURE CITED


Strategies in Science and Mathematics. Ithaca, New York: Cornell University (distributed electronically)


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Figure 1. Phase I - Ideas About Science Survey
1. Scientists use evidence to support their ideas.

2. Scientists will make new discoveries that change the ideas written in our textbooks.

3. Science is a process of discovery through observation.

4. Scientists use imagination and creativity in their work.

5. I feel that my family’s religion disagrees with the science I learn in school.

6. I feel that my family’s culture disagrees with the science I learn in school.

7. I consider myself a science person.
   
a. Anyone can be a scientist.

Figure 2. Phase II – Science Reflection Questions
1) Agree or disagree with the sentence: Scientists use evidence to support their ideas.
1) If your friend said “Scientists only make discoveries by observing them…”
What would you say to them?

2) So, do you think about scientists using imagination and creativity in their work?? Why or why not?
   How do they use imagination and creativity?
   When do they not use these things?

3) Let’s switch topics a bit and return to a question that you wrote about before. Tell me a little bit about your family’s religion and culture relates to the science you’re learning in school?
   What do you think about the connections between religion and science?

4) If someone asked you “Do you consider yourself a science person?” What would you say to them?
   Why?
   How have your ideas about yourself and science changed since you were younger?
   How do you think you’ll feel about this question when you’re in high school?

5) What else about your ideas about science do you want to share with me?

Figure 5. Phase III Interview Questions
Figure 6 “I feel that my family’s religion disagrees with the science I learn in school.” Likert responses from the Phase I students, n=69.
Figure 7 “Scientists use imagination and creativity in their work.” Likert responses from the Phase I students, n=70.
Figure 8. “I consider myself a science person.” Likert responses from the Phase I students, n=69
<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Gender</th>
<th>Self Reported Religious Affiliation</th>
<th>Self Reported Ethnicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daniel</td>
<td>M</td>
<td>Christian</td>
<td>Mexican</td>
</tr>
<tr>
<td>Renee</td>
<td>F</td>
<td>Christian</td>
<td>African American</td>
</tr>
<tr>
<td>Tom</td>
<td>M</td>
<td>Buddhist/Christian</td>
<td>Chinese American</td>
</tr>
<tr>
<td>Jason</td>
<td>M</td>
<td>Christian</td>
<td>African American/Caucasian</td>
</tr>
<tr>
<td>Ava</td>
<td>F</td>
<td>Methodist</td>
<td>Samoan</td>
</tr>
<tr>
<td>Nancy</td>
<td>F</td>
<td>Christian</td>
<td>Pilipino</td>
</tr>
<tr>
<td>Lindsay</td>
<td>F</td>
<td>Christian</td>
<td>Chinese American</td>
</tr>
<tr>
<td>Marianne</td>
<td>F</td>
<td>Baptist</td>
<td>African American</td>
</tr>
<tr>
<td>Dora</td>
<td>F</td>
<td>Jehovah's Witness</td>
<td>Pilipino/African American</td>
</tr>
<tr>
<td>Angela</td>
<td>F</td>
<td>Jewish/Catholic</td>
<td>Latin Am/Caucasian</td>
</tr>
<tr>
<td>Jane</td>
<td>F</td>
<td>Christian</td>
<td>Chinese American</td>
</tr>
<tr>
<td>Sarina</td>
<td>F</td>
<td>Christian/Catholic</td>
<td>Pilipino</td>
</tr>
<tr>
<td>Charlie</td>
<td>M</td>
<td>Buddhist</td>
<td>Cambodian</td>
</tr>
<tr>
<td>Aadam</td>
<td>M</td>
<td>Muslim</td>
<td>Moroccan</td>
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</table>

Table 1 Phase II: Individual Student Interviews - pseudonyms, gender, self-reported religion and ethnicity.
<table>
<thead>
<tr>
<th>“I feel that my family’s religion disagrees with the science I learn in school”</th>
<th>1 Strongly Agree</th>
<th>2 Agree</th>
<th>3 Neither Agree or Disagree</th>
<th>4 Disagree</th>
<th>5 Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase II Students n=68</td>
<td>1%</td>
<td>13%</td>
<td>44%</td>
<td>27%</td>
<td>15%</td>
</tr>
<tr>
<td>n=1</td>
<td>n=9</td>
<td>n=30</td>
<td>n=18</td>
<td>n=10</td>
<td></td>
</tr>
<tr>
<td>Phase III Interview Group n=14</td>
<td>7%</td>
<td>14%</td>
<td>29%</td>
<td>21%</td>
<td>29%</td>
</tr>
<tr>
<td>n=1</td>
<td>n=2</td>
<td>n=4</td>
<td>n=3</td>
<td>n=4</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. “I feel that my family’s religion disagrees with the science I learn in school.” Likert responses from the Phase I students and the Phase II interview group
<table>
<thead>
<tr>
<th>&quot;Scientists use imagination and creativity in their work&quot;</th>
<th>1 Strongly Agree</th>
<th>2 Agree</th>
<th>3 Neither Agree or Disagree</th>
<th>4 Disagree</th>
<th>5 Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase II Students n=69</td>
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<td>46%</td>
<td>34%</td>
<td>13%</td>
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<td>n=2</td>
</tr>
<tr>
<td>Phase III Interview Group n=14</td>
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<td>50%</td>
<td>29%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
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<td>n=7</td>
<td>n=4</td>
<td>n=1</td>
<td>n=1</td>
</tr>
</tbody>
</table>

Table 3. “Scientists use imagination and creativity in their work.” Likert responses from the Phase I students and the Phase II interview group.
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;I consider myself a science person.&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase II Students n=68</td>
<td>16%</td>
<td>53%</td>
<td>21%</td>
<td>9%</td>
<td>1%</td>
</tr>
<tr>
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<td>n=36</td>
<td>n=14</td>
<td>n=6</td>
<td>n=1</td>
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<tr>
<td>Phase III Interview Group</td>
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<td>38%</td>
<td>24%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
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<td>n=5</td>
<td>n=5</td>
<td>n=3</td>
<td>n=0</td>
<td>n=0</td>
</tr>
</tbody>
</table>

Table 4. "I consider myself a science person." Likert responses from the Phase I students and the Phase II interview group