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How Do Preservice Teachers' Religious Beliefs Affect Their Understanding of Astronomy?

by **Jesus Rodrigo F. Torres**

Rizal Technological University, The Philippines

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Abstract

This article describes research on conceptions of preservice science teachers in their fourth year of undergraduate studies relating to: whether Earth is the center of the Universe; whether the sky is a literal vault or dome; whether Earth is flat or round; the timeline of the formation of the Universe; and the age of the Earth. The results, which indicate that religion has a strong influence on teachers' astronomical beliefs, are quite startling and potentially helpful to professors of astronomy who have an opportunity to correct preservice teachers' misconceptions before these teachers go into the field.

1. INTRODUCTION

In teaching astronomy to preservice science teachers at Rizal Technological University, the only university in the Philippines that includes astronomy in the curriculum for students who wish to become science teachers at the elementary and secondary levels, I encounter many questions from disbelieving students about the age and size of the Universe; the Earth as the center of the Solar System and the Universe; evolution; the sequence of creation and the time it took God to create all things; and even whether the Earth is flat or round, among others. Some of the questions have been totally unexpected, such as when a student asked if I could show him heaven because they were informed by their religious leaders that astronomers have already seen it through telescopes. Despite my best efforts, some students remain skeptical.

After they earn their degrees and pass the licensure examination for teachers required by Philippine law, these students will teach in the elementary and high schools. Their beliefs will affect how and what they will teach. The bachelor of secondary education in general science degree curriculum prepares students to teach such fields as chemistry, Earth science (which includes astronomy topics), biology, zoology, and physics. If students' beliefs do not align with scientific findings, errors will be passed on to generations of

young people or reinforce those already existing.

I got the idea for this research after reading and rereading Matthew Bobrowsky's 2005 article, "Dealing with Disbelieving Students on Issues of Evolutionary Processes and Long Time Scales." In his introduction, Bobrowsky identified two kinds of disbelieving students: those who are vocal about their disbeliefs, and those who choose to keep silent. Bobrowsky realized the difficulty in identifying the second group. Bobrowsky then suggested "that instructors be prepared with strategies to recognize indicators of disbelief." He could not be more correct in stating that "some of those students are future K–12 teachers, and it is certainly important that teachers get it right."

Bobrowsky's article summarizes the varieties of creationism. Many questions asked by my former students dealt with creationism issues, such as those concerning long cosmic time scales, how the Universe was created, whether the Earth is the center of the Universe, whether the Earth is young or old, and similar questions. To find out whether my astronomy students' views fell under any of the creationist categories enumerated by Bobrowsky, I devised a questionnaire. Knowing their creationist preconceptions, I would be in a better position to anticipate their questions and to offer solutions to their difficulties on the subject.

It might be a difficult process to correct the misconceptions. Deborah Hanuschin (n.d.) noted that "a teacher who expects to simply point out students' mistakes to them will be met with little success . . . misconceptions are not easily given up." She further elaborated that "the first step is to be aware of and diagnose students' misconceptions." This is precisely what I have attempted in this research, and there were some startling revelations.

What are misconceptions? Alistair Fraser (n.d.) explained that they are "preconceived notions, non-scientific beliefs, mixed conceptions, or conceptual misunderstandings." Fraser continued, "In science these are cases in which something a person knows and believes does not match what is known to be scientifically correct." Misconceptions are "especially concerning," according to Fraser, because "we continue to build knowledge on our current understandings." Fraser warned that "possessing misconceptions can have serious impacts on our learning." A further concern, Fraser noted, is that people are not aware that their ideas are incorrect: "When they are told they are wrong, they often have a hard time giving up their misconceptions—especially if they have had a misconception for a long time." It is not the teaching of science that is difficult. "It is fairly easy," said Fraser, "my difficulties are with reeducation," especially in teaching students "about something they have learned incorrectly."

Biology misconceptions are listed on the New York Science Teacher (2008) Web site (see the URL listed in the Resources section); some are similar to the misconceptions of the respondents in this study.

Biology Misconceptions

1. Coral reefs exist throughout the Gulf and North Atlantic waters.
2. Dinosaurs and cavemen lived at the same time.
3. Acquired characteristics can be inherited.
4. Winter weather can be predicted by studying the thickness of the fur of some animals.
5. Humans are responsible for the extinction of the dinosaurs.
6. Some human races have not evolved as much as others.
7. Evolution is goal-directed.

8. Evolutionary changes are driven by need.
9. The Garden of Eden is where human life began.
10. Human beings did not evolve from earlier species of animals.

Bobrowsky (2005) suggested that teachers should be prepared to answer questions, and I think that teachers will be better prepared to answer those questions if they anticipate them at the start of the semester. Many Filipino students are silent in class. They may not ask questions but still maintain misconceptions about scientific issues and continue to maintain them even when going through the motions of studying the lessons.

2. METHOD

I devised a questionnaire to find out the preconceived beliefs of the respondents. Some passages from the Bible were used, particularly those that students may use to support creationist beliefs. I consulted with religious leaders of several Christian denominations to determine which passages might have such a use. The Biblical passages that appear in the questionnaire are those that the leaders thought would have the greatest relevance to creationism.

To test the validity of the questionnaire, it was first administered to some Rizal Technological University science faculty members. I wanted to find out if there were some ambiguous portions or questions that may confuse the respondents. After the faculty members completed the questionnaire, I met with them to discuss it. I then administered the final draft of the questionnaire to the respondents.

I chose only preservice teachers who were in their fourth and final year of studies leading to the bachelor of secondary education in general science degree and who had not yet taken up the course Science 3 (Introduction to Astronomy) in their program. The total number of respondents was 102. All respondents belong to various Christian denominations.

The students were instructed to choose the best answer from the choices given in the questionnaire. They were encouraged to give answers to all the questions unless they did not have a clear idea about a particular question. A discussion of their answers was conducted before actual astronomy topics were covered in class.

Science is being taught in Philippine schools from the third grade up to the collegiate level, to include fundamental astronomy concepts.

3. REVIEW OF RELATED LITERATURE

Brunsell and Marcks (2005) stated in their research that "many assume that teachers know the 'stuff' they are supposed to teach." We cannot be too confident about this because not all teachers teach subjects that are in line with their majors or minors. The two researchers discovered that most of the participants in their study did "not have a strong conceptual grasp of the scale of either the Solar System or the Universe." Furthermore, they explained that "most of the participants do not have an accurate grasp of the relative distance between the Earth and the Moon, and many of the participants have a disproportionate view of the scale of the Solar System compared with the distances between observable stars." Thus, the authors concluded that it is important for "professional development designers and facilitators [to] have an understanding of the knowledge base of their audience."

Andrew Fraknoi (2005) cited several findings of the Gallup Poll on Americans' understanding of evolution. According to Fraknoi, "National polling data bear out that many people really don't understand what scientists mean by a theory, or what evidence is in favor of evolution or the age of the universe." Many people I encounter consider theory as "merely theory," or "just a theory," by which they mean that it has no scientific basis. In explaining what a theory is, the American Astronomical Society (AAS), in a 2005 letter to the *Astronomy Education Review*, clarified that "A scientific theory is not speculation or a guess—scientific theories are unifying concepts that explain the physical universe." The AAS advocates teaching in schools the scientific theories on evolution, the formation of the Universe, the formation of the Solar System, and the like. According to the AAS statement,

Evolution is a valid scientific theory for the origin of species that has been repeatedly tested and verified through observation, formulation of testable statements to explain those observations, and controlled experiments or additional observations to find out whether these ideas are right or wrong. Astronomical observations show that the Universe is many billions of years old (see the AAS publication, *An Ancient Universe*), that nuclear reactions in stars have produced the chemical elements over time, and recent observations show that gravity has led to the formation of many planets in our Galaxy. The early history of the solar system is being explored by astronomical observation and by direct visits to solar system objects. Fossils, radiological measurements, and changes in DNA trace the growth of the tree of life on Earth. The theory of evolution, like the theories of gravity, plate tectonics, and Big Bang cosmology, explains, unifies, and predicts natural phenomena. Scientific theories provide a proven framework for improving our understanding of the world.

Intelligent design, the AAS explained, must not be taught in schools as a valid alternative theory to the history of life for the following reasons, as revealed in its statement:

Although scientists have vigorous discussions on interpretations for some aspects of evolution, there is widespread agreement on the power of natural selection to shape the emergence of new species. Even if there were no such agreement, "Intelligent Design" fails to meet the basic definition of a scientific idea: its proponents do not present testable hypotheses and do not provide evidence for their views that can be verified or duplicated by subsequent researchers.

Since "Intelligent Design" is not science, it does not belong in the science curriculum of the nation's primary and secondary schools.

Edward Prather, Timothy Slater, and Erika Offerdahl (2002) conducted research in which they found that "more than half of the students who stated that they had heard of the Big Bang also provided responses that they believe that the Big Bang was a phenomenon that organized pre-existing matter." Seventy percent of their respondents believed that matter existed prior to the Big Bang. The researchers concluded that most of the respondent-students employed the "phenomenological primitive," or p-prim, which was "consistent with the idea that 'you can't make something from nothing.'" These preexisting notions, according to the researchers, "are poised to interfere with instructional efforts about contemporary physics and astronomy topics."

In a similar study entitled "Fundamental Misconceptions in Cosmology" (2007), which involved a survey of nine high school and college science teachers at Rizal Technological University in the Philippines, Torres found that some respondents understood the Big Bang to be the beginning of the Solar System; a nebula that exploded that created the Solar System; the beginning of the Universe from a nebula that

exploded; a state when atoms were compacted and electrons were in an excited state, followed by an explosion; the theory of the discovery of the Universe; the primordial atom that exploded; and a meteorite that hit some planets in the Universe. To the question on what existed before the Big Bang, the respondents answered gases; one massive object consisting of helium, hydrogen, and others; that only space and energy, helium, hydrogen, and oxygen surrounded the Earth before the Big Bang; a vacuum; molecules and dust; and no time and space. Torres concluded that the respondents really did not have a clear understanding of the Big Bang. The university, in cooperation with the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and the Philippine Astronomical Society, immediately organized a seminar on the Big Bang with the respondents as participants.

4. FINDINGS

This section reveals the preservice science teachers' responses regarding the five most common issues that I encounter in my astronomy classes. The first issue concerns the question of whether the Earth is the center of the Universe. Even in our so-called modern days of advanced science, it is to be expected that some people will insist that the Earth is the center of the Universe despite this notion having been discredited a long time ago (Table 1). The second issue is whether the sky is a literal solid vault or dome with heaven above it. The third issue is whether the Earth is round, as taught by science, or flat, as implied in some passages of the Bible. The fourth issue is how long it took for the Universe to form. The fifth issue is the age of the Earth.

4.1 Is the Earth the Center of the Universe?

Table 1. Is the Earth the Center of the Universe?	
(a) The Earth is immovable, and the Sun, Moon, and the stars revolve around it because it is stated in Psalms 96:10 that "the earth is set firmly in place and cannot be moved." This means that the Earth is the center of the Universe.	32 or 31.37%
(b) The Biblical passage stated in (a) must have a different meaning because the Earth moves in space, such as revolving around the Sun.	26 or 25.49%
(c) The writer of the Biblical passage could not have known, based on the scientific knowledge at the time the passage was written, that the Earth moves in space all the time.	33 or 32.35%
(d) The Biblical passage is erroneous.	7 or 6.86%
(e) I am not sure.	4 or 3.92%

In the postresearch conference that I conducted with the students, some who agreed with item (a) told the members of the group that they have the impression that the Biblical passage mentioned is enough justification to confirm what they have believed for a long time: that the Earth is the center of the

Universe. I asked if their religion had anything to do with such a belief. Their answer was in the affirmative, or at least that was their understanding of their beliefs on this issue. Two students said that the presence of the Biblical passage was too hard to dispute and that it was easy enough to understand, even if the passage apparently is not in harmony with what they have been taught since the elementary grades: that the Earth revolves around the Sun. Their agreement with the Biblical passage is more like a conditioned response connected with a deeply ingrained trait of obedience and respect for authority. Adding the responses in items (b), (c), and (d), 66 students, or 64%, reflected the church lessons they had been taught. Table 1 also shows that four students were not sure about their answer on the issue.

Do Filipino values influence the answers of the students? In the article, "Social Values and Organization"(n.d.), this trait of Filipinos is explained as follows:

The great majority of the Philippine population is bound together by common values and a common religion. Philippine society is characterized by many positive traits. Among these are strong religious faith, respect for authority, and high regard for *amor proprio* (self-esteem) and smooth interpersonal relationships. Philippine respect for authority is based on the special honor paid to elder members of the family and, by extension, to anyone in a position of power.

"Authority" in this context includes religious leaders and, by extension, the Bible. The inclusion of a Biblical quotation might have triggered this kind of response from the students. Filipinos live in highly authoritarian social and familial structures. Obedience to authority is a much desired value ("Authority in the Culture" 2008). Religious leaders are among those in authority, and there are instances in which children will defy parents in obedience to their religious leaders. Therefore, in the presence of a religious leader wielding a Bible, Filipinos seem to be easy to convince. If a science teacher and a religious leader offered seemingly inconsistent statements about issues pertaining to science, and the science teacher supported his or her statement with scientific facts, the religious leader would still have the advantage, as I found out in discussions with the students. This may be the case not only for Filipinos.

I always emphasize that the Earth is not the center of the Universe, based on current scientific understanding. The history of how the Earth was thought to be the center of the Universe should be explained carefully to the students. In discussions that occur whenever this topic is raised, some students will point out, based on their own understanding of the Bible, that it is quite clearly stated in Psalms 96:10 that the Earth is the center of the Universe.

It might be counterintuitive to many students to note that the Universe has no center. Students think of the Big Bang as occurring in a definite point somewhere in the Universe. The teacher should carefully explain that before the Big Bang, there was no Universe, so when the Big Bang occurred, the Universe came into being with it. Direct the students to http://spaceplace.nasa.gov/en/kids/ phonedrmarc/2003_june.shtml; this site from NASA addresses this topic in clear and simple manner that should be easily understood by students of introductory astronomy.

4.2 Is the Sky a Literal Solid Vault or Dome?

Table 2. Is the sky a literal solid vault or dome?	
(a) In Job 22:14 it is written that God "walks on the dome of the sky." In Ezekiel 10:1, the dome is described as "the dome over the heads of the living creatures and above them was something that seemed to be a throne made of sapphire." These passages mean that the sky is literally a dome or solid vault where heaven is above the dome or vault and where God sits on his throne.	20 or 19.61%
(b) The sky is not a dome or vault. The writers of the Biblical passages could have merely echoed the prevailing cosmology when the passages were written.	44 or 43.14%
(c) The Bible must be wrong in this regard.	6 or 5.88%
(d) The passages must have a figurative meaning and should not be construed literally.	27 or 26.47%
(e) I'm not sure.	5 or 4.90%

Some questions that always crop up whenever I set up my telescopes to observe with my students (I cannot remember an occasion when I was not asked) are: Where is heaven? Can we see heaven through a telescope? One student, a member of a local Christian denomination, said that they were told that the "Holy City" was seen by NASA through a telescope and photographed, but NASA hid the photograph from the public because it might cause too much controversy.

Many students are pretty much convinced that there is a crystal dome between what we can see in the sky, and heaven (Table 2). In my survey, it was revealed that 20 students still believe that the sky is literally a dome or solid vault and that heaven is above the dome. Three of the students who gave this answer told me later that it could not be otherwise. Heaven could not be below our feet, they said, so it must be above our heads. The Bible, they added, reveals in numerous passages that heaven is above our heads.

In explaining this topic to the students, I have learned to always have my copy of Richard Dibon-Smith's *Starlist 2000.0* as a ready reference for stellar distances, luminosity, and diameters, as well as other data that students may ask about, such as apparent and absolute magnitudes and stellar spectra. If they do not ask, I discuss the data with them to give them an understanding of what they are seeing through the telescope. For distances and other important facts about deep-sky objects, especially the galaxies, I always bring with me Robert Strong and Roger Sinnott's *Sky Atlas 2000.0 Companion*. Often, however, there are planets to view, so we bring with us Ian Ridpath's *Stars and Planets* and my copy of *Voyages to the Planets* by Andrew Fraknoi, David Morrison, and Sidney Wolff, which has a very useful and informative set of appendixes. I think that all introductory astronomy teachers should have these books, even if they teach at the high school or lower levels. I keep the books ready in a bag that I can grab for use in observations.

Prior to making actual observations with telescopes, I find it very useful to have the class do a scale model of the Solar System. With some variations in the materials to represent the Sun and the planets (we use a volleyball to represent the Sun), the scale model suggested by Guy Ottewell (<http://www.noao.edu/education/peppercorn/pcmain.html>) is excellent, provided you have enough space, or you might just go out to a field. The Web site <http://www.vendian.org/mncharity/dir3/solarsystem/> has additional scale models to choose from.

The sheer distances that the Ottewell scale model portrays give the students an idea of how big the Solar System alone is. Ottewell goes beyond the Solar System and discusses the comparative diameters of some known stars—for example, Betelgeuse, and even the distances of the stars in a globular cluster. The effect on the students is an overwhelming awe of the distances that separate the stars from each other and of the size of the Universe. With these teaching techniques, I have never heard a student ask again about the crystal dome or heaven. By this time, they likely understand that this course is not the proper venue for those questions.

4.3 Is the Earth Flat?

Table 3. Is the Earth flat?	
(a) In Revelation 7:1 it is stated that "After this I saw four angels standing at the four corners of the earth...." The Earth has four corners, therefore it is flat. It could not have four corners if it is spherical.	9 or 8.82%
(b) The Earth is spherical. The Biblical passage should not be interpreted literally.	34 or 33.33%
(c) The Earth is not flat, it is spherical. The writer of the passage must have merely echoed the prevailing beliefs at the time the passage was written.	55 or 53.92%
(d) I am not sure.	4 or 3.92%

Nine students answered that the Earth is flat (Table 3); one of these students told me later that the Biblical passage gave her second thoughts about the real shape of the Earth. She had always known that the Earth is spherical, as she had been taught since the elementary grades, but this information must be wrong in the light of the Biblical passage mentioned in the questionnaire. That the Earth is spherical might strike a science teacher as a fact that everybody in the world knows by now and that does not need to be explained anymore. It is more striking to discover that some preservice science teachers, just one year away from being full-fledged science teachers, could have the idea that the Earth is flat!

One way to demonstrate to the students that the Earth is not flat is to show images of the curvature of the Earth taken from a high altitude. A lot of these images are available on the Internet. I also have a fine book that shows some very early pictures of the curvature, the 1964 edition of *The Flammarion Book of Astronomy*. I always show my students the pictures without assuming that they already know that the Earth is spherical. I was told by one member of the Philippine Astronomical Society that ships going to

Manila Bay become visible as they approach—further proof that the Earth is spherical—but I haven't confirmed this for myself. When I do, I will bring my students to the pleasant Rizal Park and watch the famous Manila sunset—and the ships too.

A good way to demonstrate the shape of the Earth is to use a solar or lunar eclipse, but these are quite rare and may not occur during the semester. Another method I use is to show the images of the planets and the round moons in the Solar System. If all of them are round, would the Earth be flat? The sphere is the most common shape in the Universe. There are no planets shaped like cubes or pyramids, and there are no flat planets and moons except those that have potato shapes.

One way to show the naturalness of the sphere is to ask the students to bring in a bubble-blowing toy (with one end of a wand dipped in soapy water). I let them blow bubbles and observe the shape, asking them to imagine the bubbles as planets and stars. This exercise also is helpful in demonstrating the expansion of the Universe; the bubbles separate from each other as they are blown away, illustrating the nature of open clusters, where the members tend to disperse as the cluster ages. The shape of the Earth may be elementary to us, but I learned from this research that we cannot take for granted that students already know this.

4.4 How Long Was the Process of the Formation of the Universe?

Table 4. How long was the process of the formation of the Universe?	
(a) The Universe was created by God in a literal six days based on the creation stories in Genesis.	21 or 20.58%
(b) The Universe was created in about 6,000 years because it is written in 2 Peter 3:8 "that with the Lord, 'a day' can mean a thousand years, and a thousand years is like a day."	47 or 46.07%
(c) The age of the Universe cannot be computed based on 2 Peter 3:8. The process of the formation of the Universe has been going on for about 13–15 billion years since the Big Bang.	15 or 14.70%
(d) I am not sure.	8 or 7.84%

Only 91 of the 102 preservice science teachers answered this question, and the results are very disturbing. Twenty-one respondents answered that the Universe was created in a literal six days, and 47 answered that the Universe was created in 6,000 years because it is so stated in the Bible, as they understood the Biblical passage (2 Peter 3:8). Eight answered that they were not sure.

Later, I asked the students why they thought one day means 1,000 years, and some answered "because that's what we are told in church"! I asked if they were taught by their science teachers that the Universe is about 13–15 billion years old based on the reckoning of science, and almost all of them answered that they could not remember. One student said that they were taught about the age of the Universe, but he just listened to the lesson without believing what the teacher said because he had been told by his religious

leaders since he was young that the Universe was created in just 6,000 years. Two students countered that the Universe was created in just six literal days because that is what the Bible says! One student told me that he was instructed by the religious leader of their congregation to just sit quietly whenever this topic is discussed, not ask questions, and not believe either.

Only 15 students (about 15%) answered that the formation of Universe has been going on for 13–15 billion years.

I then asked, "What will you teach your students when the time comes?" They answered they would teach what they believe. We have some real problems here.

I found out through experience that it is not very effective to confront the beliefs of the students head-on. Convincing them about the findings of science requires much patience and a well-laid strategy. The strategy is simple enough. The semester should be long enough to change their minds. I emphasize the length of time needed for the formation of the Solar System, for example, based on the evidence of science. The age of the Earth has been proved in part by fossil evidence. Stellar evolution can be shown firsthand to the students by actual stargazing and explaining to them how the age of a particular star is determined partly by its color as seen through the eyepiece.

Using redshift is another way of explaining to the students the expansion of the Universe and the time that lapsed in its continuing expansion. I also keep a copy of the AAS statement on the teaching of evolution or direct them to the AAS Web site (<http://aas.org/policy/teachevolution.php>). Patience and perseverance is the key, but we should always be ready to answer questions from disbelieving students.

4.5 How Old Is the Earth?

Table 5. How old is the Earth?	
(a) The Earth is about 10,000 years in age according to the evidence in the Bible.	19 or 18.63%
(b) The Earth is about 4.5 billion years according to the reckoning of science.	55 or 53.92%
(c) The Earth is young, but it only appears old because God can create old things and young things as He wishes. For example, He created Adam and Eve as adults right away.	14 or 13.73%
(d) I am not sure.	4 or 3.92%

This question relates to Question 4, though I was a bit confused about the students' answers. I asked them after the survey why they believe that the Universe was created in just six days or 6,000 years, but most of them still believe that the Earth is 4.5 billion years old based on the reckoning of science. The answer proposed by one student is that God did not take much time creating the Universe, but the Universe itself and the Earth are old.

However, it should be noted that 19 of the students answered that the Earth is just 10,000 years old according to what they perceive is indicated in the Bible. Are these students aware of the movement called Young Earth Creationism (YEC)? I asked the students if any of them was aware of such a movement, and no one said yes. They were just told by their religious leaders that the Earth could not be more than 10,000 years old. One student informed the class that his religious sect used quite sophisticated arguments to prove the young age of the Earth, but he could not follow them very well.

I instruct my students to study the matter further by reading the Wilkinson Microwave Anisotropy Probe (WMAP) Web site (http://map.gsfc.nasa.gov/universe/uni_age.html). Another Web site useful for explaining this issue in a simple and understandable manner is http://www.space.com/scienceastronomy/age_universe_030103.html (Britt 2003). Other very useful Web sites explain this topic scientifically, but I found out, to my dismay, that there are far too few compared with the number of Web sites that advocate a young Earth. The YECs seem to be more aggressive in promoting their beliefs. We in science education are being put on the defensive. I think that this issue should be given priority in introductory astronomy discussions. Again, we cannot take for granted that students already know the scientific facts on the issue, despite being taught them since elementary grades.

The responses also revealed that 14 students might be believers in the Omphalos Argument, which provides, according to the explanation of David Wise (1990), that "The earth only appears to be ancient because it was recently created with the appearance of great age. It isn't that the scientists have gotten the story wrong, it's just that they don't realize that it is ONLY a story."

The students who replied in this way, as I learned from our discussions, apparently did not really understand the argument. They told the class that they were told by their religious leaders that it was the truth. Two even argued that God could do as he wishes, such as create new things to appear young, or young things to appear old. At this point, I let go of the discussion. There would be enough time during the semester to point out the facts in a persuasive and calm manner.

5. RECOMMENDATIONS

Based on the findings of the survey, I would like to present the following recommendations and suggestions, in addition to those given previously:

1. We don't have to wait for disbelieving students to argue with us; I think we should know who they are right from the start of the semester. The best way is to distribute a questionnaire. This way, we will be prepared to answer whatever questions on creationism they will ask us.
2. The educator cannot be impatient when answering questions about creationism. He or she must bear in mind that the students are in the class to learn. Gone are the days when our words as teachers must be taken by the students, whether they like them or not, as the truth. Nowadays, we have a lot of convincing and persuading to do, and we should be able to back them up by hard, scientific evidence. We should take an inventory of the creationist questions from our students. We should turn the questions over and over in our minds with the intention of trying to discover the most effective method of explaining answers to our students.
3. A semester should be long enough to persuade students of the facts. One method of teaching that may backfire is lecturing from a position of authority; some students feel, on the subject of creationism, that their religious beliefs are at stake, and they will defend them vigorously, if not with their lives. A teacher should avoid offending the religious sensibilities of students because if he or she does, it will

be very hard to regain harmony in the class. The teacher will be looked upon by the offended students as an adversary from then on. It is better to avoid arguing from the standpoint of religion or being drawn into a religious debate.

4. Introductory astronomy teachers should have a ready list of the astronomical arguments of creationists. Matthew Bobrowsky's (2005) article in the *Astronomy Education Review* is particularly useful for this. There may be other arguments not included in the article, though, so it would be better if we familiarize ourselves with such arguments. There are many creationist Web sites; they greatly outnumber Web sites on the scientific aspects of the age of the Universe. These scientific Web sites tend to be buried under an avalanche of creationist Web sites, so we should know how to direct our students to the scientific Web sites.

Resources

Web Sites

American Astronomical Society. 2005, "Statement on the Teaching of Evolution"
<http://aas.org/policy/teachevolution.php>

"Authority in the Culture"
<http://www.livinginthephilippines.com/philculture/authority.html>

Bobrowsky, M. 2005, "Dealing with Disbelieving Students on Issues of Evolutionary Processes and Long Time Scales"
<http://aer.nao.edu/cgi-bin/article.pl?id=143>

Britt, R. R. 2003, "Age of the Universe Revised, Again"
http://www.space.com/scienceastronomy/age_universe_030103.html

Brunsell, E., & Marcks, J. 2005, "Identifying a Baseline for Teachers' Astronomy Content Knowledge"
<http://aer.nao.edu/cgi-bin/article.pl?id=119>

Fraknoi, A. 2005, "The Challenge of Creationism and Intelligent Design: An Introduction"
<http://aer.nao.edu/cgi-bin/article.pl?id=142>

Fraser, A. "Bad Science"
<http://www.ems.psu.edu/%7Efraser/BadScience.html>

Hanuschin, D. "Misconceptions in Science"
<http://www.indiana.edu/~w505a/studwork/deborah/#4>

Hinshaw, G. F. 2008, "How Old is the Universe?"
http://map.gsfc.nasa.gov/universe/uni_age.html

Lunar and Planetary Institute. "Solar System: Planets, Moons, Comets, Meteors"
http://www.lpi.usra.edu/education/resources/s_system/s_system.shtml

NASA: The Space Place. "Where Is the Center of the Universe?"
http://spaceplace.nasa.gov/en/kids/phonedrmarc/2003_june.shtml

New York Science Teacher. "Biology Misconceptions"
<http://www.newyorkscienceteacher.com/sci/miscon/common-miscon/bio.php>

Ottewell, G. 1989, "The Thousand-Yard Model, or Earth as a Peppercorn"
<http://www.noao.edu/education/peppercorn/pcmain.html>

Philippines: Country Studies. "Social Values and Organization"
<http://countrystudies.us/philippines/41.htm>

Prather, E., Slater, T., & Offerdahl, E. 2002, "Hints of a Fundamental Misconception in Cosmology"
<http://aer.noao.edu/cgi-bin/article.pl?id=26>

Vendian Systems. "A Solar System Model Meta Page" (various Web sites on scale models of the Solar System)
<http://www.vendian.org/mncharity/dir3/solarsystem>

Wilkinson Microwave Anisotropy Probe (WMAP)
http://map.gsfc.nasa.gov/universe/uni_age.html

Wise, D. C. 1990, "The Omphalos Argument"
http://members.aol.com/dwise1/cre_ev/omphalos.html

Articles and Books

Chaisson, E., & McMillan, S. 2004, *Astronomy Today*, Englewood Cliffs, NJ: Prentice Hall.

de Grasse Tyson, N. 1997, *Merlin's Tour of the Universe*, New York: Doubleday.

Dibon-Smith, R. 1992, *StarList 2000: A Quick Reference Star Catalog for Astronomers*, Wiley.

Fraknoi, A., Thompson, D., & Wolff, S. 2004, *Voyages to the Planets*, Brooks Cole.

Garlick, M. A. 2006, *The Illustrated Atlas of the Universe*, Sydney: Fog City Press.

Ridpath, I. 1998, *Stars and Planets*, London: Dorling-Kindersley.

Sparrow, G. 2001, *The Universe and How to See It*, London: Marshall Editions Ltd.

Seeds, M. A. 2003, *The Solar System* (3rd ed.), Canada Thomson Learning

Strong, R. A., & Sinnott, R. W. 2001, *Sky Atlas 2000.0 Companion*, Cambridge University Press.

Torres, J. R. F., 2007, *Astronomy: An Introduction for Filipino Students*, Mandaluyong, The Philippines: Rizal Technological University, <http://www.rtu.edu.ph>

Volpe, P. E., & Rosenbaum, P. A. 2000, *Understanding Evolution* (6th ed.), Boston: McGraw-Hill.

References

American Astronomical Society 2005, "Statement on the Teaching of Evolution," <http://aas.org/policy/teachevolution.php>, accessed August 1, 2008.

"Authority in the Culture." 2008, *LivinginthePhilippines.com*, <http://www.livinginthephilippines.com/philculture/authority.html>, accessed August 1, 2008.

Bobrowsky, M. 2005, "Dealing with Disbelieving Students on Issues of Evolutionary Processes and Long Time Scales," *Astronomy Education Review*, 4(1), 95. <http://aer.nao.edu/cgi-bin/article.pl?id=143>.

Britt, R. R. 2003, "Age of Universe Revised, Again," *Space.com*, http://www.space.com/scienceastronomy/age_universe_030103.html, accessed August 1, 2008.

Brunsell, E., & Marcks, J. 2005, "Identifying a Baseline for Teachers Astronomy Content Knowledge," *Astronomy Education Review*, 3(2), 38. <http://aer.nao.edu/cgi-bin/article.pl?id=119>.

Flammarion, C. 1964, *The Flammarion Book of Astronomy*, G. Camille Flammarion & A. Danjon (Editors), New York: Simon and Schuster.

Fraknoi, A. 2005, "The Challenge of Creationism and Intelligent Design: An Introduction," *Astronomy Education Review*, 4(1), 90. <http://aer.nao.edu/cgi-bin/article.pl?id=142>.

Fraknoi, A., Thompson, D., & Wolff, S. 2004, *Voyages to the Planets*, Belmont, CA: Brooks/Cole.

Fraser, A. n.d., "Bad Science," <http://www.ems.psu.edu/%7Efraser/BadScience.html>, accessed August 1, 2008.

Hanuschin, D. n.d., "Misconceptions in Science," <http://www.indiana.edu/~w505a/studwork/deborah/#4>, accessed August 1, 2008.

New York Science Teacher 2008, "Biology Misconceptions," <http://www.newyorkscienceteacher.com/sci/miscon/common-miscon/bio.php>, accessed August 1, 2008.

Prather, E., Slater, T., & Offerdahl, E. 2002, *Hints of a Fundamental Misconception in Cosmology*, *Astronomy Education Review*, 1(2), 28. <http://aer.nao.edu/cgi-bin/article.pl?id=26>.

Ridpath, I. 1998, *Stars and Planets*, London: Dorling-Kindersley.

"Social Values and Organization." n.d., *Philippines: Country Studies*, <http://countrystudies.us/philippines/41.htm> accessed August 1, 2008.

Torres, J. R. F. 2007, "Fundamental Misconceptions in Cosmology," *RTU Academic Journal*, 1(5).

Wise, D. C. 1990, "The Omphalos Argument," http://members.aol.com/dwise1/cre_ev/omphalos.html, accessed August 1, 2008.

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25 - 39