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Abstract

This thesis analyzes four current educational philosophies: perennialism, progressivism, existentialism, and constructivism. Particular attention is paid to their impact on science education. Each philosophy is examined for its philosophical roots, educational theory, science education goals, science education methodology, and science curriculum. It is then critiqued in light of a Reformed Christian perspective. In the discussion, I propose a Reformed philosophy of science education.

Introduction

Christian science teachers face decisions every day about the methods and materials they will use in their classrooms. Should they use discussion or discovery learning? Should they use textbooks or trade books? What topics should they include in their science lessons? How should their classrooms be different from those of non-Christian teachers? Their answers to these questions are usually based on their goals for science teaching and learning, and these goals are rooted in educational philosophies.

This paper analyzes four current educational philosophies: perennialism, progressivism, existentialism and post-modern constructivism. Many aspects of each philosophy will be examined, including philosophical roots, impact on general education, and impact on science education methodology, science curriculum, and science education goals. The author will examine these philosophies in light of a Reformational worldview for science education. The author will conclude by suggesting a distinctively Christian philosophy for science education.

Problem

Teachers' actions and choices reflect their own goals and philosophies. It is important for teachers to know what philosophical roots their goals have. It will help the teachers see more clearly the impact of their decisions on their students. Educators can also examine if their practices and goals are aligned with the goals of the parents and school. Educational philosophies can be seen as the foundation of a pyramid of classroom education. Curriculum, goals, and methodology are all built upon these basic principles. Educators should make sure their curriculum and methods are aligned with their educational philosophy or they will be sending mixed messages to their students.

This is especially challenging for Christian educators. Christian science teachers often attempt to use secular textbooks and popular teaching strategies without stopping to consider if these textbooks and strategies fit within the Christian worldview of science education. What does this worldview look like? How does it differ from other current philosophies and practices? These are the questions this paper seeks to address.

Current Educational Philosophies

Perennialism

Philosophical Roots

As Knight, author of *Philosophy and Education* (1998), suggests, Perennialist education focuses on the importance of using the mind, reasoning, and studying the great works of the past. One key to understanding the perennialist view of education is the concept of liberal education. Knight (1998) goes on to explain that "liberal education in the classical tradition revolved around those studies that made people free and truly human, as opposed to the training that people received to do specific tasks in the world of work" (p. 108).

Perennialism has its roots in the philosophy of Neo-scholastism. Neo-scholasticism is a modern form of Scholasticism, which developed during the Middle Ages. Scholasticism follows the wisdom and teachings of Aristotle, who taught that the universe has order and design and also believed in cause and effect relationships. Thomas Aquinas (1225-1274) was the leading Scholastic who sought to blend Aristotelian reason with Christian theology. "The basic approach developed by Aquinas was that a person should acquire as much knowledge as possible through the use of human reason and then

rely on faith in that realm beyond the scope of human understanding" (Knight, 1998, p. 51). Neo-scholastics believe that there is absolute truth in the universe. The mind must be trained to think if it is to reach that truth.

Educational Philosophy

Perennialist philosophers such as Mortimer Adler and Robert Hutchins have taken the beliefs of the Thomas Aquinas and applied them to the field of education. The student is seen as a rational being who has the potential to acquire knowledge and truth. They believe the responsibility of the school is to help the student develop that potential. The perennialists also believe that people are essentially sinful in nature (Howick, 1980). Therefore, there should not be too much freedom in the classroom. Adults know what is important for students to study.

Perennialism is subject-centered. In his book *Paideia Proposal* (1982), Adler advocates that education should be the same for all students. Adler proposes a threefold course of study that is to be completed by all students. The first component or mode of learning is acquisition of organized knowledge. This is accomplished by means of using lectures and responses, textbooks, and other aids. The second mode of learning is the development of intellectual skills, such as reading, writing, calculating, observing, measuring, and speaking. This is accomplished by coaching, drill, and supervised practice. The third mode of learning is an enlarged understanding of ideas and values. This is accomplished by questioning and discussion of real books. Schools that follow this philosophy have a focus on the basic subjects and offer very few electives. There is also little emphasis on vocational training (Knight, 1998).

The teacher's role is an authoritarian role. It is the teacher's responsibility to decide to which set of knowledge students are to be exposed. Teachers are viewed as mental disciplinarians capable of developing reason, memory, and will power in their students (Knight, 1998). In a Christian setting, teachers are also viewed as leaders in the realm of faith.

Education in a perennialist setting is very structured and logical. Many leading perennialist educators favor a return to a classical concept of education, which used the "trivium" of grammar, logic and rhetoric stages (Knight, 1998). Classical schools and the Paideia Project are two examples of the recent use of perennialist philosophies in K-12 education ("A Classical Curriculum," 1996). Proponents of classical education argue that at the grammar stage (grades 1-4) the mind is ready to absorb facts, and students still find memorization to be fun. At the logic stage (grades 5-8), students are beginning to think analytically. These students focus on looking for relationships between the facts learned in the grammar stage and begin to look for cause and effect. At the rhetoric stage (9-12), students learn to write and speak with force and originality. These students apply the rules of logic to the information learned in the grammar stage and express their conclusions.

Three very important perennialist educators were Mortimer Adler, Robert M. Hutchins, and in the ecclesiastical realm, Jacques Maritain. Adler (1902-2001) was a professor, philosopher, and educational theorist. He was a proponent of a liberal arts education that should be the same for every child. In his book *Paideia Proposal* (1982), Adler describes his vision for American public schools: that all children acquire knowledge, skills, and understanding of ideas and values. While a professor at

University of Chicago, Adler along with Robert Hutchins, the college president, led the charge to revive interest in studying the "Great Books of the Western World". They believed that the great works of the past were filled with wisdom that has applications today.

Robert Hutchins became the president of the University of Chicago in 1929, at the age of 30. He encouraged a liberal education, and discouraged emphasis on nonacademic pursuits. He remained at Chicago until 1951, and then worked at Encyclopedia Britannica until his retirement. He edited a 54 volume, *Great Books of the Western World* (1952).

Science Education Goals

To be educated in science, a student should know basic scientific facts, think deeply about scientific topics and act on scientific knowledge in a personal, original and independent way ("A Classical Education", 1996). The goal for elementary science is to learn facts about the natural world (creation). The goal for middle school science is to teach students to use the scientific method and apply it to the knowledge they have learned.

High school science is concerned with reading classic works by Galileo, Copernicus, and other great scientists, along with performing laboratory work, so that students can understand the history behind these discoveries. High school students are also able to speak and write logically about scientific topics. Another important goal of high school science for the perennialist is to create an appreciation for our cultural heritage in the scientific realm. The perennialist's hope is that studying the works of the great scientific minds will lead students to develop their own scientific minds.

Science Education Methodology

The methods of teaching science in a perennialist classroom require considerable structure on the part of the teacher. There is much memorization, observation of nature, and direct instruction at the elementary level. Basic science skills such as observing, measuring, and estimating should be taught through coaching and drilling (Adler, 1982). Young students should not be asked to analyze science concepts or look at causes and effects. The focus should be on attainment of science facts. In the middle and high school, laboratory activities should be used, but they should be controlled and teacher led. Direct instruction should also be used at the middle and high school level, along with discussion and study of the great scientists.

Science Curriculum

At the elementary level, nature study is encouraged. Students should learn facts about all parts of the created world. Bauer suggests in her book, *The Well Trained Mind* (1999), that students study science topics on a four-year cycle: life science, earth science/astronomy, chemistry, and physics. This is planned to coincide with a four-year cycle of studying world history. She suggests this will help integrate science topics into other areas. For example, astronomy should be studied at the same time as the history of scientific discovery and the church's relationship to science in medieval church history. Adler, in *Paideia Proposal* (1982), suggests that studies in the natural sciences should include biology, chemistry, and physics. These topics should not be taught in isolation; rather their interconnectedness and interdependence should be stressed.

Christian Critique

Most Christians agree with the perennialists that there is absolute truth. Secular perennialists, however, would disagree that this truth is found in the Bible. Most Christians would also agree that critical thinking skills are very important in dealing with life's issues. We do need to be cautious because many perennialists value human reason above faith in God (Howick, 1980).

As Christians, we know that knowledge of the mind is important, but it is not the only kind of knowledge a Christian must possess. In Christ's eyes, knowledge should also be an affair of the heart. Van Brummelen, author of *Steppingstones to Curriculum* (2002), notes, "In biblical terms, it is our heart knowledge and commitment that governs our minds and our rationality" (p. 28).

Another concern is the view of education as directed solely to the academic sphere of the student. The social, emotional, spiritual, and physical aspects of the student are not addressed in this philosophy of education. Students should be viewed as integrated beings because that is how they were created. Education should include the whole student.

This philosophy does not encourage students to view the societal aspects of science. We must lead our students to view all subjects, including science, in light of their responsibility as stewards and culture-formers. If their only view of science is one of past discoveries, they may not be prepared to fulfill their role as Kingdom citizens.

Progressivism

Philosophical Roots

Progressive education is child-focused. Progressive educators believe that children are naturally curious about the world around them. Education should start with that curiosity. Progressive educators also view school as part of society, and education as part of life, rather than preparation for life.

Progressivism in education has its roots in pragmatism. Pragmatism is a modern philosophy that developed as a reaction to the traditional philosophies. Pragmatism developed about one hundred years ago, when America was experiencing urbanization, industrialization, and migration. Change was everywhere, and pragmatism was one reaction to the changing world. "William James (1842-1910), a leading pragmatist, defined pragmatism as, 'the attitude of looking away from first things, principles, categories, supposed necessities; and of looking towards last things, fruits, consequences, fact'" (Knight, 1998, p. 54-55). There was such an explosion of knowledge that people started questioning the wisdom of looking for absolutes. The pragmatists claim that reality is not fixed. What is thought to be real today may change tomorrow. Rather, they emphasized empirical science to find out about the world around them (Knight, 1998).

Pragmatists believed that the only way to know about reality is through human experiences. "Truth is what works" is another important belief to the pragmatist. Because the earth is changing so rapidly, what is true today may not be true in the future. Truth is relative, and this relativity also extends to values. Society determines what values are important, and those values may change as the dominant culture changes.

Educational philosophy

John Dewey (1859-1952) was a leading philosopher of pragmatism who sought to apply the pragmatic thoughts to the area of education. From 1894-1904, Dewey taught at University of Chicago in the areas of philosophy, psychology, and education. Dewey believed that the scientific method should be applied to education, and he tested out his theories at the Laboratory School he founded at the University of Chicago. Dewey wrote several books on progressive education. In 1904, Dewey moved to Columbia University where he remained until his retirement in 1930 (Ansbacher, 2000).

Progressive educators believe that students, not subject matter, should be at the very heart of the educational process. They believe that education should be a part of life, not just a preparation for life. Since the world can only be known through experiences, they feel that schools should help students experience real life. They also advocate educating the whole child, not just the mind. The student and his ideas should be treated with respect and should not be hindered (Howick, 1980).

They also believe that the school is a social institution which extends democratic ideals (Lucas, 1976). Education focuses on each student's interests and capabilities as a participating member of society. Progressive educators emphasize curriculum with socially oriented content. Knowledge is not just for thinking about; it is an instrument for solving problems and managing the world (Peterson, 1986). For this reason, progressive educators prefer procedural subjects to ones that are content centered. They emphasize problem-solving skills that are usable in a changing world.

Progressive educators also reject the perennialist's view of an authoritarian teacher who is concerned with transmitting knowledge to her students. To a progressive

educator, truth is dynamic and relative. Therefore, it is a waste of time memorizing information that might not be true long-term. They argue that a teacher's role should be that of an advisor or guide. The educator provides the best environment possible so that his or her students can experience reality. The teacher uses the student's natural curiosity to help him learn the skills he needs to live in society. This encourages students and teachers working together, rather than opposing one another.

Science Education Goals

A primary goal for science education for the progressive educator is the application of scientific principles to society. An additional goal is the study of science that emphasizes the personal and social relevance of science. The rise of progressivism in the 1920's and 1930's, between the wars, turned many educators' attention to the need for students to realize the uses of science in their everyday lives. Science education should enrich the personal development of students and help them in their roles as citizens (Matthews, 1994).

Science Education Methodology

Progressive educators are very opposed to the rote memorization and recitation methods utilized by the perennialists. In his book *Democracy and Education* (1916), Dewey encourages teachers to use experiential teaching methods to teach science:

> There is a strong temptation to assume that presenting subject matter in its perfected form provides a royal road to learning. What more natural than to suppose that the immature can be saved time and energy, and be protected from needless error by commencing where competent inquirers have left off? The outcome is written large in the history of

> education...The pupils learn a "science" instead of learning the scientific way of treating the familiar material of ordinary experience...The method which begins with the experience of the learner...is often called the "psychological" method in distinction from the logical method of the expert. The apparent loss of time involved is more than made up for by the superior understanding and vital interest secured. What the pupil learns he at least understands. (p. 220-221)

This is a result of the belief that the only way we can know reality is through our experiences. The progressive educators also stress the scientific method as a way to find out about the world. They emphasize problem solving and the project method (Howick, 1980). Other teaching strategies advocated by this philosophy are field trips and cooperative learning. Progressive educators seek to minimize the amount of competition and individualism in the classroom.

Science curriculum

In the progressive science classroom, emphasis is placed on studying the scientific method and how it relates to everyday experience. When content is taught, there is an increased focus on the study of social problems and the practical application of science to daily life. Subject matter should not be rigidly isolated into separate subjects, but should be studied as integrative units about real life. Science-related topics might include environmental issues, technology, medicine, chemical warfare, genetic engineering, or alternate energy resources.

Christian critique

A large concern with progressivism is the denouncement of absolute truth. Progressivists believe that truth is relative and dynamic. It changes as society changes. Progressivism also rejects moral absolutes. It holds that values must be created by the consensus of society, not discovered. We know that God has given us truths that should guide our thoughts, words, actions, and educational beliefs. Another problem with the progressive educators is their dependence on the scientific method. Progressivism substitutes a certain method (scientific method) for the certain truths argued for by the perennialists (Morris, 1966).

There are other aspects of progressivism that many Christian educators can embrace. The first is taking a closer look at child development when planning educational activities. Young children learn best through concrete experiences such as experiments, field trips and projects. We should employ these strategies while helping students discover truths about God's creation. Nurturing Christian educators need more than a set of concepts to be transmitted. They also need an understanding of how students interact with reality at different levels of development (Steensma and Van Brummelen, 1977).

A second point of agreement is found in the inclusion of societal issues in the science curriculum. It should be noted, however, that a Christian teacher's motives for including these issues in the curriculum are different. Progressive educators believe that the study of social problems will lead students to be better prepared to be democratic citizens. Christians believe the study of societal issues will lead students to identify and

experience God's unique calling for humans to develop science and technology as cultural activities that honor God and His creation (Van Brummelen, 2002).

Educational Humanism/Existentialism

Philosophical Roots

Educational humanism has its roots grounded in the philosophy of existentialism. It also shares some beliefs with pragmatism. Existentialism in America was influenced by European existential philosophy after World War II. The individual is at the heart of existentialism. People are defined by the work they do to invent themselves as free and responsible humans (Bertrand, 1995). To the existentialist, each man is an island. The perennialist can lean on logic or the ancient truths, and the pragmatist relies on the community, but the existentialist is individually responsible for his or her own choices (Knight, 1998). In the area of ethics there are no absolutes. Each man chooses what he thinks is right and then is responsible for the choices and actions he makes. Important existentialist philosophers include Soren Kierkegaard, Friedrich Nietzsche, Jean-Paul Sartre, and Carl Rogers.

Educational philosophy

Morris, in his book *Existentialism in Education* (1966), suggests "if education is to be truly human, it must somehow awaken awareness in the learner—existential awareness of himself as a single subjectivity present in the world" (p. 110). The student has the role of the "selector" by deciding what he will study and how much he will learn. He is not an imitator of his teacher and should not be concerned about following the crowd. This view of education is based on the belief that man is innately good.

According to this philosophy the worst thing a teacher can do is impose preformed habits, beliefs and values on the child before he is old enough to understand and make judgments about them. Knight (1998) suggests that existential education should focus on helping children become self-actualized—developing their full potential. Hopkins (1981) goes on to explain that student enthusiasm would be considered success in the existentialist classroom. Existentialists reject the belief that children are objects to be worked over and brought in line with what their teachers think they should be. They also argue that all other educational philosophies direct the process of education mainly toward the outside of the child. Even the progressive philosophy, which claims to be child-centered, ultimately looks at the student in relation to other students or community (Morris, 1966).

In the humanist classroom, the teacher's first role is to help students have enriching experiences and then help the students understand them (Bertrand, 1995). Freedom in the classroom is plentiful because learning is private and personal. The teacher promotes both freedom of choice and responsibility of choice. Existentialist philosophers speak of an "existential moment." This is the moment when a person first senses the feeling of responsibility for his own actions and choices. This "existential moment" usually occurs in the late elementary or middle school. Thus, existentialists are focused on education at the middle and high school level (Morris, 1966). Ultimately, the responsibility for creating learning rests with the learner.

Three educators who have embraced this educational philosophy are A.S. Neill, Carl Rogers, and William Glasser. A.S. Neill started the Summerhill School in England, which is based on existential principles. William Glasser wrote the book *Schools Without Failure* (1968) which urged schools to develop warm, nonthreatening environments to

fulfill students' needs for love and self-worth. Carl Rogers wrote *Freedom to Learn* (1969), which described an existential view of methodology. Although extreme existentialism is rare in classrooms today, many of the elements described above can be found to a certain degree.

Science Education Goals

In the existential philosophy, the primary goal of science literacy is not to acquire or have any scientific content, but to create a context that will hold such knowledge. In his article, "Science Education – 1: The Spirit of Science" (1993), Pollak gives this explanation:

> The context of scientific literacy involves 'being' a scientist in the sense of developing and operating out of certain attitudes, skills, and understandings and also involves developing a conceptual framework which transcends specific scientific knowledge, but within that scientific knowledge (content) can be functionally accommodated. (p. 514)

Existentialists advocate a "being" mode rather than a "having" mode of learning. As the student is 'being' a scientist, the acquisition of knowledge of science information will occur naturally. Teachers should seek to develop in their students scientific attitudes of doubt, critical thinking, and ultimate reliance on evidence.

Science Education Methodology

Existential educators use very little direct instruction and lecture. Those methods tend to attempt to transfer knowledge from the teacher to the student. This is not acceptable for the existentialist. Methods in the science classroom include individual instruction, small groups, discussion questions, and laboratory work. The goal is to

encourage openness, use of imagination, and critical thinking. Another teaching strategy used by existential teachers is the Socratic method. The Socratic method is a question-discussion approach to learning. Existential teachers are careful when using this method because their goal is not for the student to agree with the teacher, but for the student to form his own thoughts and feelings (Howick, 1980).

Science Curriculum

Morris, author of *Existentialism and Education* (1966), explains, "The curriculum is not there to be mastered (as the traditionalist would say), nor is it there to be experienced (as the experimentalist would say). It is there to be chosen. The subject matters and experiences in a curriculum shall be merely available; to be learned, they must first be opted for, sought out, and appropriated by the student" (p. 124). When a student does choose a topic to study, he is encouraged to explore all aspects of the topic, including the controversial issues. Students are led to raise questions about good and bad, right and wrong. Students are given the opportunity to assert a personal view about any topic. There are few academic requirements because that limits student choice of topics. Therefore, there is little that is uniform in the area of science curriculum, because it would vary from classroom to classroom and student to student.

Christian critique

There are several aspects of an existential philosophy of education that are not compatible with the Christian worldview. The first aspect is too much focus on the individual. As Christians, we live in community, and want our students to live and model community in the classroom.

A second criticism of existentialism is the assumption about the nature of the student. Existentialists assume that the student is inherently good in nature. This is evident in their belief that children are always naturally motivated to learn and figure things out if placed in a good environment. Christians acknowledge the sinful nature of all people, including students. Students need discipline, nurture, and instruction to do what is right according to the Lord and His word.

As with progressivism, existentialism also embraces relativism. Christian educators reject this attempt to reject the absolute laws God has laid forth in his Word.

Lastly, let us recognize that one of our responsibilities as stewards of creation is to systematically study the structure and design of the creation. Leaving the science topics to be studied totally up to the students is not an appropriate response to this calling. Science curriculum does not have to be tightly controlled by the teacher, but there must be goals for exploring and discovering all aspects of creation, not just the areas individual students wish to study.

Constructivism

Philosophical Roots

Constructivism refers to a philosophical view about the nature of reality and perception. It purports that we make our own worldview and knowledge. Reality, it says, is a personal construction. What we hold true will be based on what works for us. Ideas are not seen as true or false because there is no way to know if everyone's ideas about the reality of nature are congruent (Coburn, 2000). Constructivism as an

educational philosophy that finds it roots in Jean Piaget and in the postmodern philosophies.

Piaget is said to be the father of constructivism (Crowther, 1997). His ideas and theories for a child's psychological development provide the foundation for the learning theory espoused by constructivism. Piaget said that students organize and adapt all new information they receive to fit in with what information is already present in their minds. The adaptation of information is either one of assimilation of new information into existing structures, or accommodation of existing structures to fit new information.

Some postmodern philosophers have taken this theory a step further. They reason that since each student assimilates and accommodates the same information in different ways, knowledge must be a human construction, unique to each person's life situation. Postmodern philosophy is also characterized by several other beliefs. It rejects the ideas of objective truth, universalism, and are skeptical of current metanarratives (grand historical stories). Postmodern philosophers avoid the scientific method and favor instead, intuition, feelings, and creative play (Walsh, 1997). Postmodern tendencies have shown up in science education in two main forms: "robust multiculturalism" and "radical constructivism". Matthews (1994) refers to "robust" multicultural science education to mean that local or ethnic ideas about nature are recognized as legitimate alternatives to universally held scientific beliefs. Postmodern thought holds that every voice should be heard equally. The term "radical constructivism" refers to the belief that all knowledge and reality is relative. Good, in his article "Perspectives on Postmodernism and Science Education", says this of constructivism, "The science of science education can be de-

emphasized or changed to allow the curriculum to be defined in terms that are more convenient, more flexible, more postmodern" (p. 6).

Constructivism is relativistic by its very definition. Matthews, author of *Science Teaching: The Role of History and Philosophy of Science* (1994), states that the two core beliefs of constructivism are:

1) Knowledge is actively constructed by the cognizing subject, not passively received from the environment.
2) Coming to know is an adaptive process that organizes one's experiential world; it does not discover an independent, preexisting world outside the mind of the knower (p. 141).

We do not find truth, but construct viable explanations of our experiences.

Educational Philosophy

As mentioned above, constructivists believe that all knowledge is constructed by students as a result of experiences provided by their teacher. This leads us to define the role of the teacher. Some constructivist philosophers view teachers as social activists who are out to change the status quo by helping students take personal and social responsibility for the future. The teacher is not seen as merely a presenter of information, neither is he seen as a one who merely provides a learning environment for discovery learning. A constructivist teacher does a combination of these things. He develops a relationship with his students that will encourage them to explore, question, and make sense of their experiences (Driver, 1995).

Students are not seen as passive receivers of knowledge. They are viewed as active learners who come to a science lesson already having ideas about the natural

world, which they use to understand everyday experiences. Constructivists view science knowledge as a set of socially negotiated understandings of the events that make up the experienced universe (Crowther, 1997).

Science Education Goals

Students' ideas should be as important to explore as the normal scientific laws and theories. The purpose of a science class should be to encourage a richer understanding of the workings of the physical world, one that requires the articulation and investigation of one's own ideas as well as the ideas of others (Fosnot, 1996). Leading a student to explore, question, and hypothesize are also goals of science education. Transmitting already discovered science knowledge is not a goal of constructivism and is seen as a detriment to students.

A constructivist classroom focuses on student understanding and use of scientific knowledge, ideas, and inquiry processes. There is an emphasis on understanding and responding to each student's interests, strengths, experiences and needs. This is complemented by a classroom community that values cooperation, shared responsibility and respect for others (National Research Council, 1996).

Science Education Methodology

Constructivist philosophers have suggested several teaching strategies that will encourage and promote construction of scientific knowledge by students. Many of these strategies fall under the heading of scientific inquiry. These strategies include cooperative learning, problem-based learning, discussion and reflection, and use of inductive learning. Students must have the opportunity to articulate their ideas, test them, and look for connections to prior knowledge (Fosnot, 1996).

Saunders (1992) proposes a four-step approach to teaching science constructively. The first step is using inquiry labs to engage students. The second step is active cognitive involvement. This step involves meaningful learning activities such as thinking out loud, interpreting data, development of alternative hypotheses, and suggesting and designing further experiments to test. The third step is small group activity that is intended to stimulate critical thinking to lead students to construct knowledge about the topic being investigated. The final stage involves higher-level assessment. Saunders (1992) suggests this could include one of many forms of alternative or authentic assessment, rather than a traditional test. Examples of alternative assessment are projects, reports, presentations, problem solving, models, and essays that allow students to demonstrate what they have learned. Since all students may construct knowledge in a different but equally valid way, an assessment that emphasizes right and wrong answers would not be appropriate.

Constructivist philosophers also encourage the problem-centered learning method. This method allows students to answer the question/problem as is right for him or her, considering their life situation. The teacher remains neutral and does not correct alternative conceptions (Crowther, 1997).

Science Curriculum

Constructivist teachers think that the usual scope and sequence of curriculum hinders their ability to help students to understand complex concepts. The usual curriculum has too much information in it (Brooks and Brooks, 1993). The topics that are studied should be relevant to students. Constructivist teachers also advocate for the integration between science disciplines. They argue that this helps students find connections among the experiential world (Crowther, 1997). Constructivists would move

away from packaged curriculum and study those subjects that have particular meaning for their students. According to this philosophy, the knowledge science teachers are concerned with is the student's knowledge, not content knowledge (Fosnot, 1996).

There is also a greater emphasis on the development of process skills within the science curriculum (Smolicz and Nunan, 1975). These skills are crucial if students are to construct knowledge and make it personally meaningful. Elementary students should focus on actual scientific life and what scientists do, not on the study of their finished products (Smolizc and Nunan, 1975).

Another area of emphasis in a constructivist classroom is multicultural science education. Constructivists believe that because everyone's beliefs are equally valid, each culture's scientific ideas should be studied. For example, the study of medicine would not be dominated by Western medicine. Students would also learn about Eastern medicine and Native American medicine. Similarly, the study of outer space might include many cultures' views of the sun and stars and their importance.

Christian Critique

I will begin by discussing several areas in which most Christian educators can agree with the ideas and emphases of the constructivists. Constructivists view the child as an active participant in the educational process. They encourage respect for the child and his thoughts and beliefs. This harmonizes with a biblical view of the child where children are image bearers of God and as such deserve our respect. Children are also integrated beings, and as such, should be taught to look for and recognize the interconnected nature of creation. Christian educators would also agree with their

emphasis on building community, rather than competition, in the classroom and developing mutual respect.

Another point many Christians can accept is the de-emphasis of the faith placed in reason and the scientific method. The modern philosophers place much faith in the method of science, and in doing so, take away from the faith that belongs to God.

While several points mentioned above may seem to agree with a Christian perspective, the motives behind these points do not. Constructivism has carried human construction of knowledge to the extreme (Knight, 1998). From the postmodern perspective, even the concept of God is a social construct. Many constructivists believe that all knowledge is constructed by humans, not revealed by our Creator. What is moral or has value in our society depends on the consensus of its members.

Postmodernism is critical of all metanarratives or grand stories. Postmodernist philosophers see metanarratives as social constructions (stories) developed by dominant groups to legitimize their position and oppress minority groups (Knight, 1998). This includes the truths found in the creation, fall, and redemption messages of Scripture. "Yet it is precisely this story that we must tell in a postmodern culture. In the face of the dissolution of all grand stories, Christians have the audacity to proclaim the liberating story of God's redemption of all of creation" (Walsh, 1997, p. 15).

Christians educators also reject the postmodern views of relativism and moral instability. We know that absolute truth exists and we know its Author. We believe there are absolute moral standards that should guide one's actions. Brian Walsh, in his essay "Education in Precarious Times: Postmodernity and Christian World View" (1997), affirms this: "Biblical ethics...are always set within the context of our covenantal

relationship with God, as they express the commitment and faithfulness of a God who is always in the fray with us, always setting out for us the paths of healing, restoration, and reconciliation" (p. 13).

Discussion

How then should a Christian educator teach science? In this section, I propose a Reformed Christian philosophy for science education that includes philosophical roots, general educational theory, science methodology, science curriculum, and science education goals. It is important for Christian science teachers to realize that their curricular and methodological choices reveal their educational philosophies. Teachers should always be ready to explain the reasons behind their classroom choices and actions.

Philosophical Roots: Christian Worldview

Worldviews tell a story. The Biblical worldview tells the story of the creation, fall, and redemption. In his book *Science in Faith* (1998), Jones states, "We must help our children to find their place in a biblically and personally meaningful world. They must come to know it all as one true story which is also their story" (p. 5).

The whole world has been created by God for his glory. He created all things, including man, and lovingly provides for all his created beings. God has given humans the task of caring for and developing the earth for His glory. God's judgment after Adam and Eve's sin, and our continuous sin have impacted the creation. Christ's death and resurrection brought redemption to all of creation. We are called to bear witness to the ongoing, redemptive work of Christ.

The only reason we can know anything is because the One who has given meaning to all things has created us to do so. Thus, we look to the Word of this Creator to give us direction for all areas of our life.

Christian Educational Philosophy

The Christian science teacher acts as a guide for her students. She helps them discover the structure and design that God intended for the various parts of creation. She enables them to search out ways that sin has affected the creation and encourages them to discover ways they can respond to that distortion. In his essay "Teaching our Education students to teach Christianly" (1997), Van Dyk states, "Teachers are to prepare for knowledgeable and competent, responsible discipleship, the sort of discipleship that equips our students to function as God's children in all areas of life" (p. 42). Van Dyk sees the role of the teacher as a three-fold role of guiding (modeling, encouraging, disciplining), unfolding content and skills, and enabling students towards discipleship by encouraging works of service. Christian teachers do not seek to merely indoctrinate their students; rather, they seek to help students attain knowledge and experiences that will help promote Christian thinking and action.

A Christian worldview also has many implications for the role of the student in the educational process. Students are made in the image of God. This suggests that students are active and purposeful beings like their Creator. Students are also rational, creative problem solvers who should have an active role in their education (Graham, 1997). Children learn according to their natures. Therefore, they must be given the opportunity to make some decisions in the classroom. Students are also sinful human

beings. Therefore, they need guidance in recognizing their sinful nature and redirection from sinful actions.

Another biblical concept that affects Christian educational philosophy is the centrality of the heart to the educational endeavor. The heart, not the mind, is at the very center of the educational process. Graham, in his essay "Biblical Faith and Classroom Learning" (1997), puts it this way: "The heart is the very essence of our being, that place in which our understandings, commitments, beliefs and actions reside and from which they arise. If teaching is to foster learning it must be aimed at the heart" (p. 12). Knowledge should not reside only in the minds of our students. We must strive to make sure it reaches the hearts of our students. Beliefs that are accepted by our hearts lead to action in God's kingdom.

Science Education Goals

A primary goal of science education is for students to acknowledge that God is the Creator of all things, living and nonliving. Above all, we want this truth to govern our science classrooms. Our science teaching should lead students to investigate the orderliness and complexities of the creation.

Another goal of science education is to help students explore their role as caretakers of creation. The cultural mandate in Gen. 1:28 calls all Christians to care for and protect the creation. In order to respond to this call, our students must know about the different parts of the creation. In the book *Science in Faith* (1998), Jones states,

> When we celebrate the natural sciences, it is for the wonders of God's creation that they reveal. When we receive with gratitude the knowledge and understanding that they provide, it is because they help us in our tasks as stewards

and servants of God's Earth. We are responsible and accountable before God for our lives. (p. 1)

Along with our calling to protect and preserve the creation, God has also called us to the task of developing His creation. Van Brummelen (2002) says that one goal of science education is "to identify and experience God's unique calling for humans to develop science and technology as cultural activities that honor God and His creation" (p. 209). This means that students need to learn to apply what they have learned to the appropriate area of creation.

Students should also be taught that because science is a human activity, it is fallible. Theories or models we believe correct may need modification in the future. God has allowed man to discover many things about His creation and the way it works. We must impress upon our students the importance of using these tools of science to further God's Kingdom, not hinder or destroy it.

Science Education Methodology

Quality Christian science teaching reflects both the nature of the learner and the nature of the subject being taught. Students are created to image an active and purposeful God. These attributes are respected in the science classroom. Students are allowed to explore many parts of creation in an active way. Students are allowed to make some decisions about what is learned and how it is learned. They are encouraged to apply what they are learning to the world around them. We should not treat students as passive learners and be content with filling their minds with our knowledge (Graham, 1997).

Christian science teaching utilizes many teaching strategies. In his book *Steppingstones to Curriculum* (2002), Van Brummelen says, "Students do learn much

about science through hands-on activities. Good science programs focus on investigating questions and problems that learners can relate to their everyday lives" (p. 208). Investigations and hands-on explorations should be at the heart of any science program. Creation is all around us. Students should be allowed and encouraged to experience it firsthand. They should be allowed to pose problems and investigate possible answers.

Another important teaching strategy in the science classroom is cooperative learning. This strategy can be used in several applications. It can be used with lab investigations, projects, and simulations. This strategy emphasizes the Christian principle of community. Group members are responsible for the learning of others in their group. This strategy also allows for students to share their particular gifts for the benefit of others. Skills such as drawing, organization, memory, getting along with others, and public speaking can be used for the group effort.

Simulations and models also have an essential role in the science classroom; they allow students to study parts of creation that are not easily accessible to them due to size or location. An example would be using the simulation *Rainforest Researchers* (Tom Snyder Productions) in a unit on ecology and environmental stewardship. This simulation allows students to think critically, solve problems, and make choices about the stewardship of this unique habitat.

Direct instruction is appropriate in some circumstances, usually in upper grades. In his essay "Teaching to Teach Christianly" (1997), Van Dyk cautions, "Direct instruction has a place but must be used with caution. Its excessive use, especially of lecturing and note-taking, breeds passivity, and passivity is incompatible with active Christian discipleship" (p. 46).

Through the teaching methods a teacher selects, she strives to help students uncover the wonders of creation. She then guides students to apply the creational truths they discover to their task as developers of creation. A teacher cannot force students to think critically and apply their knowledge, but she can create experiences and an environment that encourages these tasks.

Science Curriculum

God created both living and nonliving things on the Earth. Thus, a scientific study of creation should include both of these areas. The four main categories of science include biology, physical science, earth science, and health/human body. All of these topics should be explored in the elementary years. They do not have to be taught as separate topics, however. As a reflection of the wholeness of our students and the connectedness of creation, our science studies should also be holistic or integrated as well. At times this could mean integrated with other subjects such as language arts or social studies. At the very least, this would mean integration between the disciplines of science.

Within each unit of study, the topic taught should be considered from a creation, fall, and redemption pattern. The first part of this pattern involves studying the structure and design (purpose) with which this topic was created. The second part of the unit involves looking at how sin has affected this topic. The last part of the unit looks at ways the students can fulfill their redemptive role.

Let's look at an example of this structure. I will consider a unit on birds. The first part of the unit focuses on discovering how and why God created birds. The students look at the diversity of birds God created and birds' role in His creation.

Students might explore the biology of a bird's body, the physics of flight, the ecology of different bird habitats, what feathers do and how they work, and the mystery of migration. The second part of the unit focuses on how sin has affected birds. Students could look at the example of the passenger pigeon and loss of habitat issues that many bird species face. The third part of the unit would call on students to determine ways that they can function as responsible disciples of God's kingdom. They will look for actions they can take and encourage others to take actions that will witness to the redemptive work of Christ.

Conclusion

Choices have consequences. Christian science teachers need to make their choices very carefully. There are many methods and curricula available for teaching science. All of these should be carefully examined to determine if they are aligned with a Christian philosophy for teaching science. Christian teachers have an awesome responsibility to their students, their students' parents, and most of all, to their heavenly Father. It is my hope that this paper has explained several of the current educational philosophies in the area of science education and that this knowledge will make it easier for teachers to make godly choices in their science classrooms.

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