

Science Teachers' Worldviews: A Way to Understand Beliefs and Practices

Yalcin YALAKI

Hacettepe University, Turkey

Abstract

There are many studies in the science education literature about science teacher's beliefs. Most of these studies investigate science teachers' beliefs about science and education in isolation from their larger belief system that could be called their worldview. It is suggested in this paper that it is far more useful to investigate science teachers beliefs from a worldview perspective and it is also suggested that some models of the worldview concept may provide a useful tool for personal development. Especially philosophy is a very important instrument for understanding worldviews and their development. An interpretive-qualitative study that utilized the concept of worldview in understanding four science teachers' beliefs and their way of making sense of science teaching is reported.

Introduction

Many see teachers as the main agent of change in educational reform and in raising the standards of education (Black & Wiliam, 1998; Bybee, 1993; Tobin et al. 1994). Beliefs are thought to determine the actions of prospective and in-service teachers during the teaching and learning process and if teachers are the main driving force for change and improvement, the nature of their beliefs must be understood. Researchers such as Blake (2003), Bryan (2003); Bybee (1993), Kagan (1992); Nespor (1987), and Pajares (1992) have emphasized the importance of studying teacher beliefs in educational research. Because of the emphasis made on teacher beliefs, many studies were conducted this issue in science education. Most of these studies look at teacher beliefs in relation to a particular subject or a specific case. To name a few example the following literature could be cited: teacher beliefs about constructivism (Beck, Czerniak & Lumpe, 2000; Haney & McArthur, 2002), teacher beliefs about teaching and learning (Bryan, 2003; Hashweh, 1996; Laplante, 1997; Levitt, 2002; Tsai, 2002), teacher beliefs about science-technology-society (STS) (Lumpe, 1998; McGinnis & Simmons, 1999; Tsai, 2001), teacher beliefs about the nature of science (Cobern, 2000a; Haidar, 1999; Lederman, 1992), teacher beliefs about cultural issues (Aikenhead & Otsuji, 2000; Bryan & Atwater, 2002), teachers' self-efficacy beliefs (Bandura, 1994; Barnes, 2000; Haney, Lumpe, Czerniak, & Egan, 2002; Posnanski, 2002; Ramey-Gassert, Shroyer, & Staver, 1996; Roberts, Henson, Tharp, & Moreno, 2001; Tschannen-Moran, Hoy, & Hoy, 1998), teachers beliefs about their teaching context (Lumpe, Haney, & Czerniak, 2000), and the relationship between teachers' beliefs and their practice (Blake, 2002; Pajares, 1992; Laplante, 1997; Simmons, Emory, Carter, Coker, Finnegan, & Crockett, et al., 1999; Southerland, Gess-Newsome, Johnston, 2003; Sweeney, Bula, & Cornett, 2001).

Looking at teacher beliefs from a wider perspective could be more useful in understanding teacher beliefs and the relationship between beliefs and practices. That wider perspective could be the concept of *worldview*. In this paper, I make a case for a possible future direction in teacher education research by reporting a qualitative study about teacher beliefs that utilized the worldview concept. First it is useful to look at previous research on teacher beliefs.

Teacher Beliefs

Lumpe, Haney, and Czerniak (2000) argue that prospective teachers and in-service teachers develop their beliefs about teaching from years of experience as students and teachers and that their beliefs appear to be stable and resistant to change. One place where change may take place in teachers' beliefs about teaching and learning is the teacher education programs (Pajares, 1992). Pajares argues, "...teacher preparation programs can ill afford to ignore the entering beliefs of preservice teachers" (p. 323). He cites research that found preservice teachers having unrealistic optimism and self-efficacy beliefs before they start teaching and when they do, they face an unexpected reality. To avoid this kind of problems and to achieve desired change in teacher beliefs, it is important to put emphasis on beliefs in teacher education programs, since such change may be more difficult later on. Tobin, Tippins, and Gallard (1994) argue,

Science teachers often move through 15 to 20 years of schooling without ever being induced to think about their own beliefs about the nature of science and scientific knowledge and that which has shaped them (Gallagher, 1991). Often they are not educated to think in terms of exposing the tacit assumptions embedded in teaching practices and conventions. (Tobin, Tippins, & Gallard, 1994, pp. 62)

Looking at the previous research about teacher beliefs, it is evident that what teachers believe and what they do in their classroom is important to educators. Even though there are many studies in the literature about teacher beliefs, the concept of belief is not always defined clearly (Pajares, 1992; Southerland, Sinatra & Matthews, 2001). Tobin, Tippins, & Gallard (1994) cite the work of Oliver & Koballa (1992) who investigated the definition of belief accepted by science educators. What they found is that there is no consensus on what the concept of belief means; however, there are common elements to these definitions. As Tobin, Tippins, & Gallard explain these common elements are

...a relationship between belief and knowledge, the idea that beliefs are acquired through communication, the concept that beliefs prompt action, and continuum that reflects a range of beliefs from factual to evaluative. (Tobin, Tippins, & Gallard, 1994, pp. 55)

Pajares (1992) argues that the confusion about the concept of belief centers on the distinction between belief and knowledge. Southerland, Sinatra & Matthews (2001) agree. According to Pajares, distinguishing knowledge from beliefs is a difficult task. Southerland, Sinatra & Matthews (2001) provide a useful review of the literature on the issue. They explain how knowledge and belief are defined within different fields such as philosophy, educational psychology, and science education. They argue that the differentiation of knowledge and belief in philosophy goes back to Plato.

Plato holds a *reasoned true belief* account of knowledge that requires any proposition to meet three conditions: truth, belief, and evidence. The truth condition is a measure of whether the proposition accords with reality. The belief condition denotes whether the individual believes the proposition is true. To meet the evidence condition, the individual must have good reasons to believe that the proposition is true. (Southerland, Sinatra & Matthews, 2001, pp. 328)

According to Southerland, Sinatra & Matthews Plato's "view, in one form or another – that knowledge is *justified true belief* – has been epistemological orthodoxy since Plato's time and has dominated twentieth-century Anglo philosophy" (Southerland, Sinatra & Matthews, 2001, p.328). They explain that empiricists and rationalists have provided their version of how the evidence criteria should be met for knowledge. They go on to explain the objectivists' position that knowledge exists independent of the knower and whatever the knower think and understand is called beliefs. Radical constructivists, on the other hand, hold an opposite view of objectivists' by claiming that the distinction between knowledge and belief is an artificial construction (Cobern, 2000a).

Southerland, Sinatra & Matthews (2001) explain that psychologists are less clear about what the difference between knowledge and belief is compared to philosophers. Many psychologists argue that beliefs are more subjective and are more affective in nature. This affective feature of beliefs is suggested to be a way of differentiating knowledge and beliefs. Nespor's (1987) also argues that affect is a feature of beliefs rather than knowledge. Nespor gives this example to show that affect is not associated with knowledge: "One's knowledge of the rules of chess and various lines of play does not depend upon whether one likes or dislikes chess, whether it excites or bores one" (Nespor, 1987, p. 319). Looking at this argument, it is possible to conclude that beliefs are knowledge with attached feelings. Southerland, Sinatra & Matthews (2001) argue that the use of affect to distinguish between knowledge and belief is problematic because knowledge is not completely free from affect; therefore it is not easy to make a clear cut distinction between knowledge and belief based on affect. However, I think that affect provides a useful tool for separating knowledge and belief. Perhaps knowledge and beliefs could be thought as the two ends of a spectrum in which affect plays a bigger role on the belief side and a lesser role on the knowledge side.

According to Pajares, "beliefs are created through a process of enculturation and social construction" (Pajares, 1992, p. 316) and with time and use, beliefs become more robust and difficult to change even if it is based on incorrect or incomplete knowledge. He continues to say, "People grow comfortable with their beliefs, and these beliefs become their 'self' so that individuals come to be identified and understood by the very nature of the beliefs, the habits, they own" (Pajares, 1992, p. 318). Pajares cites Rokeach (1968) who argues that beliefs also differ in intensity and power. The more central a belief, the more intensity and power it has and the less likely it changes.

Pajares (1992) and Southerland, Sinatra & Matthews (2001) argue that a researcher, who wishes to study people's beliefs, should be clear about the definition of belief. Based on the discussions on knowledge and beliefs in the literature, it seems the most important feature of belief that sets it apart from knowledge is its personalized nature. Because there is more affect associated with beliefs than knowledge, beliefs have more meaning for individuals than knowledge. In other words beliefs are knowledge with emotions, judgments, and evaluation attached and unless challenged, they may be held more strongly over time. Because of the personalized nature of beliefs, they influence behavior more than knowledge and they are less likely to change, especially if a belief is central to a person's life. This distinction between knowledge and beliefs was assumed in this study.

Pajares (1992) argues that researchers refer to teachers' attitudes about education, schooling, teaching, learning, and students as "teacher beliefs." However, he warns that teachers have beliefs about matters that go beyond their profession and still influence their practice. He says, "When researchers speak of teachers' beliefs, they seldom refer to the teachers' broader general belief system of which educational beliefs are but a part..." (Pajares, 1992, p. 316). He also argues, "Seeing educational beliefs as detached from and unconnected to a broader belief system is ill advised and probably unproductive" (Pajares, 1992, p. 326). Based on Pajares's warning, the purpose of this study was to look at teacher

beliefs from a broader perspective, the perspective of worldviews. The theoretical perspective of this study is based on the idea that every belief that people hold is attached to a larger belief system called worldview. Cobern (1991) argues that worldview is the fundamental beliefs a person holds which he refers to as presuppositions and he makes a distinction between presuppositions and ordinary beliefs. Similarly Rokeach (1968, as cited in Pajares, 1992) argues that beliefs differ in intensity and power and some beliefs are more central to a belief system. Therefore what Cobern calls presuppositions or what Rokeach calls central beliefs form the belief system of a person that could be called the person's worldview. Worldview is shaped by the beliefs that form the fundamental organization of the mind, and knowledge is filtered through worldview before it is accepted, rejected, or modified (Kagan, 1992). The following section provides a more in-depth discussion of the worldview concept.

The Concept of Worldview

Worldview is a word that is being used very often in human sciences, including science education, yet it is seldom defined. Despite its frequent usage, few theoretical frameworks are developed to understand and study it (Kearney, 1984; Cobern, 1991). Washburn (1997), Kearney (1984), Cobern (1991) and, Graves (1981) provide different descriptions of the worldview concept. I discuss them one by one in the following.

A philosopher, Washburn (1997) talks about how one can change his/her worldview by studying philosophy in his book, *Philosophical Dilemmas - Building a Worldview*. He defines worldview as: "A worldview is a set of answers to questions about the most general features of the world and our experience of it" (Washburn, 1997, p. 6). The questions Washburn talks about address the core beliefs of people that shape their worldviews. According to Washburn, one of the goals of studying philosophy is to build a coherent worldview by trying to answer the fundamental philosophical questions in life such as:

- 1- What kind of being am I? What does it mean to be human?
- 2- What is the best way of life? What goals should I have?
- 3- How am I related to people around me? How should society be organized?
- 4- How can I find answers to these questions? What can I know with assurance?
- 5- Does religion provide the answers? Does God exist? (p. 6)

Washburn explains that these questions indicate the most basic, fundamental aspects of human experience in other words the core belief system or worldview: (1) human nature, or self and identity, (2) moral values and action, (3) society and one's place in it, (4) knowledge and understanding, and (5) transcendence. There are many possible answers to these questions and the answers accepted by a person form the beliefs, assumptions, and values that make up his/her worldview. However, Washburn argues that the concept of worldview is not simple, because each of the above questions can be broken down to more specific questions. For example related to the first question (What kind of being am I?) one can ask:

Am I free, or are all my actions caused by something outside of me? Will I survive the death of my body, or am I a physical machine, which breaks down at death? Can I know myself better than others, or do other people see my real traits better than I do? Am I basically self-centered, or basically giving and self-scarifying? (Washburn, 1997, pp. 7)

Each of these questions can be broken down to even more specific questions and all of these questions can be answered in many different ways. According to Washburn, another thing

that makes worldviews very complex is the difficulty of answering these philosophical questions. One example is “Does God exist?” People have been struggling with this question for many years and there are many conflicting answers. Washburn explains that studying or thinking about worldviews also raises many questions about worldviews themselves:

How does one acquire a worldview? Does one simply adopt the worldviews of his/her parents, teachers, or friends? Does one take one part from one source and other parts from other sources? Does everybody have one? How does one judge a worldview? Does it matter what one’s worldview is? Can one change his/her worldview? (Washburn, 1997, pp. 7)

Washburn (1997) argues that building a coherent, mature, and consistent worldview with which one can live happily is a rewarding process that takes a long time. He views worldview as a dynamic concept, which can be purposefully changed through questioning and learning, if a person has the will to do so. Obviously not every person may feel that their worldview needs change or maturing if they are comfortable with it or if they have no conflicts between their beliefs and life experiences. Many people do not normally think in depth about important philosophical questions about life or try to formulate answers for these questions. Nevertheless, Washburn offers some guidelines for the process of building a coherent worldview to succeed.

The first guideline Washburn suggests is that a worldview should be based on human experience. Many people hold beliefs that are out of date, expected of them, or flattering to their ego, but in conflict with their day-to-day experiences. He also suggests that in the process of worldview development as we try to understand our existence and our surroundings, other people’s experiences should not be ignored since they can do things and go to places that we cannot and they may have thought about things more thoroughly and deeply. So other peoples’ experiences are a source in the process of exploring answers to philosophical questions. However, this is not to say that people should accept someone else’s answers just because they sound impressive, but rather they should have good reasons for accepting an answer, reasons that are based on experience.

Another guideline that Washburn suggests is to think about how parts of our worldview fit together (the organization of our worldview). He explains that the answers we give to the philosophical questions are interconnected. For example an answer given to the question, “What kind of being am I?” is related with the answer given to the question, “What is the best way of life?” or “How should I live my life?” One may accept an answer to the first question like, “I am a combination of two things, a soul and a body.” This answer also assumes that bodies live a finite life while souls live forever and the quality of soul’s eternal life depends on how one lives now. A person who believes in this answer should live his/her life “the right way” now since the life on earth is very short compared to the eternal life of the soul. This answers the second question, “How should I live my life?” This example shows the interconnectedness of answers given to philosophical questions.

Finally a third guideline that Washburn suggests is that one should accept answers to philosophical questions that are clear and understandable. For example one can answer the question, “How should society be organized?” as “the foundation of society is each individual’s unalterable human rights and human rights should be the guiding principle of all government” (Washburn, 1997, p. 9). According to Washburn, the person who gives this answer should be able to clarify what human rights are and be able to answer these other questions: What rights do people have? Does everyone have a right to a job? To the best medical care? To make remarks that may offend someone? Why do people have rights? What is it about people that give them certain rights? Is it intelligence, moral sense, ability to make

choices, or something else? Washburn argues that if one does not know answers to these questions, then one does not know what he/she means by saying people have human rights.

In brief, Washburn defines worldview from a philosophical perspective and argues that practicing philosophy (i.e. learning through searching for answers to fundamental philosophical questions) is a useful method for building a coherent worldview. This perspective suggests that worldviews can be changed in a long and complicated but rewarding process of questioning and learning. According to Washburn building a coherent worldview is an important process, because it helps people to get to know themselves and it provides a sense of identity.

Kearney (1984) is an anthropologist who has come up with another framework for studying worldviews. His work has inspired research about worldviews in science education (Cobern, 1991). He defines human worldview as a collection of basic images and assumptions about reality that an individual or a society holds, which provide a more or less coherent but not necessarily accurate way of thinking about the world. He argues that there are three problems to deal with when studying worldviews:

- 1- What are the universal characteristics (categories within) of human worldview?
- 2- How do images and assumptions (beliefs) form within these categories?
- 3- What are the influences of worldview on social and cultural behavior? (Kearney, 1984, p. 10)

Kearney argues that in order to study worldviews, some common characteristics of worldviews should be identified and as a result of his studies he identifies seven characteristics that are common to all worldviews. These are: self, non-self, relationship, classification, causality, time, and space. Kearney calls these characteristics “worldview universals.” Even though worldview universals are common cognitive categories to all human worldviews, their content (beliefs, images, assumptions) is different from person to person or society to society.

According to Kearney’s model, self and other are the most basic characteristics of human worldview. Self is the ultimate reference point from which everything else in the universe is viewed (Cobern, 1991). Everything that is not self is the other (non-self). Kearney explains that some people may associate self with the physical body, whereas some other people may distance themselves from the body and associate the self with unseen entities such as soul.

Classification, relationship, and causality universals are the next most basic categories after self and non-self. People classify objects and concepts into many different groups and the way people classify things is part of their worldview. The most basic classification is self and non-self, beyond that people make classifications in the non-self domain (Cobern, 1991).

Relationship universal is about the relationship between self and non-self. According to Kearney (1984), people may see non-self, or parts of it, as existing to be maintained (harmony), obeyed (subordinancy), or acted upon (dominance). Environmental conditions may have great influence on the relationship aspect of worldviews. Depending on one’s life condition, one may see the non-self as threatening and life as a struggle, or one may see the non-self as peaceful and life as joyful.

According to Kearney (1984) the causality universal is related to how people perceive the reasons for natural events. For example in some societies supernatural causes are attributed to the natural events whereas in societies, where natural sciences are valued, classical physics explain the causes of natural events. Finally, how people perceive space and time constitutes the space and time worldview universal. For example, there may be differences among how space and time is perceived between people who live in urban areas

and people who live in rural areas. According to Kearney while time is perceived as circular in nature in rural societies with the succession of seasons, festivals, generations, and etc., in urban societies time is perceived as linear.

The organization of worldview universals within worldviews is what Kearney (1984) calls the *logico-structural* model of human worldview. According to this model, the worldview universals and the beliefs, ideas, and actions associated with them organize to create the structure of the worldview. The organization of universals strives towards maximum logical and structural consistency within the worldview. However, Kearney argues that it is possible to see external and internal inconsistencies within worldviews. The external inconsistency in a worldview results when its beliefs, images, or assumptions are incompatible with the perceived reality. On the other hand, internal inconsistency in a worldview results from contradictions among beliefs, assumptions or images within worldview universals. If inconsistencies in a worldview exist, they may lead to discomfort or stress and changes in the structure of the worldview toward a more consistent and logical one may take place, which is the idea behind the logico-structural model.

Cobern (1991), who bases his work about worldview largely on Kearney's (1984) worldview model, has been one of the pioneers in science education for introducing this model as a research agenda. Cobern (1991) suggests using the worldview model to try to understand how people make sense of their world may lead to improvements in teaching and learning. According to Cobern (1996), teaching scientific concepts to students is not as simple as isolating their everyday thinking, and manipulating or replacing them in order to achieve scientific thinking. He argues that students' understanding of what the world is like is based on long-held concepts (whether scientifically acceptable or not) that make sense to them and as long as they make sense to them, they have no reason to change these concepts. Cobern (1999) defines worldview as,

One knows from fields as diverse as theology, cognitive anthropology, and philosophy that a person's thinking is based on a set of first principles, so to speak. This is a worldview and it is "not merely a philosophical by-product of each culture, like a shadow, but the very skeleton of concrete cognitive assumptions on which the flesh of customary behavior is hung" (Wallace, 1970, p. 143). These assumptions or, more accurately presuppositions, exert a broad influence over one's thinking... (Cobern, 1999, pp. 542)

Cobern suggests, "worldview provides a non-rational foundation for thought, emotion, and behavior" (Cobern, 1996, p. 584). He argues that the presuppositions that constitute worldviews are subject to change with experience; however, because of their fundamental nature, presuppositions tend to be stable. Cobern (1991, 1996, 1999, 2000b) argues that understanding students' worldview may allow educators to understand the conflicts between their worldviews and the scientific knowledge being presented to them in schools. This understanding may ultimately lead to changes in curriculum and teaching methods that provide better science teaching and learning. Many scholars in science education have done similar studies, especially in relation to cultural aspects of science education (Aikenhead & Jegede, 1999; Allen & Crawley, 1998; Bryan & Atwater, 2002; George, 1999; Kawagley, Norris-Tull, & Norris-Tull, 1998; Waldrip & Taylor, 1999).

Graves, a psychologist, has developed a developmental model of values systems within humans that constitute their worldview. Beck & Cowan (2002) explain that Graves developed his theory in an effort to depict the human nature as a whole. He collected data for decades through observations, interviews, and psychological tests that provided the basis for his model. He describes his model as:

The psychology of the mature human being is an unfolding, emergent, oscillating, spiraling process marked by progressive subordination of older, lower-order behavior systems to newer, higher-order systems as man's existential problems change. (Beck & Cowen, 2002)

What this theory suggests is that, belief systems (or values systems as Graves calls it) that people hold show a developmental feature. There are levels of complexity in values systems, and each level can be described based on "perceptions about life conditions" (beliefs about what the world is like) and "mind capacities" (the mindset required to deal with the world as it is perceived) (NVC, 2001). Graves (1981) and his students Beck & Cowan (1996) identified eight main levels of belief systems or worldviews. An explanation of each level is given below based on Cowan & Todorovic (2000), Graves (1981), and Beck & Cowan (1996). Graves labeled each level with letters (given in parenthesis); however, later on Beck & Cowan, who further developed this theory, used color labels.

1. Beige (AN, automatic): This is thought to be the simplest psychological level, which is based on biological urges and drives. At this level physical senses dictate the state of being. This level is not used to describe normal human psychology.
2. Purple (BO, animistic): In the purple belief system, the world is seen as a mystical and sometimes threatening place. People find safety within the communities they live in where people look out for each other. This belief system may be common among people who live in small towns, ethnic neighborhoods, or tribal communities. Marriage and family relations are very much valued in this level and people stay committed to home and extended family relations. Spiritual beliefs, rituals, and traditions are valued in the purple belief system.
3. Red (CP, egocentric): In this level, an egocentric belief system is valued. The world is seen like a jungle where the strong dominates and the weak serve and therefore power is desired. People who value this belief system tend to assert themselves for dominance. The red belief system is common in street culture, crime organizations, and populations of emerging nations with a large purple (BO) subsystem. People who operate from a red belief system have a present time orientation, in other words what matters is now and future is not real. Small children who seek attention from adults and expect their demands be met immediately also operate at this level.
4. Blue (DQ, absolutistic): In the blue belief system, the world is perceived as an orderly place and that order has to be kept. Respect for authority, loyalty, patriotism, traditions, and rules are valued. A life style based on "one true way" and "going by the book" in dealing with problems or issues in life is a characteristic of the blue belief system. Strict religious communities, highly structured societies, or highly bureaucratic organizations are places where the blue belief system is common. People who operate from this level have a future time orientation, in other words, they believe that one needs to sacrifice now to get rewards later. In a society where the blue thinking is valued, people are expected to accept the judgment of the authority (politicians, religious leaders, parents, etc.) and play their roles to maintain a healthy society. Community needs are more important than individual needs.

5. Orange (ER, multiplistic): The world is seen as a place full of opportunities and resources in this level. People who value orange belief system have an entrepreneur perspective in life. Capitalist values, technological advancement, economic power, and competition are valued within this belief system. For people who value the orange belief system, maneuvering within the rules of an organization or a system to get ahead and testing available options in life to reach a goal are common attitudes. Business oriented communities, companies, and economically advanced or advancing nations would be places where people who value orange thinking would be common. In this belief system the priority is given to self-advancement rather than the community. Bureaucracy and heavily structured systems are not valued in this level.
6. Green (FS, relativistic): Concern for human feelings and needs is given priority in this level. People, who value a green belief system, see the world as a habitat where peace and prosperity must be achieved and maintained. Relativism, post-modernism, multiculturalism, consensus building, and well being for all are respected ideas within this system. The roles of charity organizations or international organizations such as United Nations would be valued by green way of thinking.
7. Yellow (GT, systemic): At this level people view the world as a complex system where change is the norm. World is under the threat of humans' limited vision (such as fundamentalism, violence, terrorism, pollution, global warming, wars etc.). People who value yellow thinking seek ways to fix the world's problems through knowledge, knowing that those problems also affect them. At this level people tend to have strong sense of independence, individual competence, and self-worth. They are not driven by fear, compulsiveness, or loss of status. They may express discomfort at over-simplified models and failure to recognize the true complexity of issues at hand. Systemic long-range thinking, questioning, and accepting differences are common attitudes among people who value the yellow belief system.
8. Turquoise (HU, holistic): The turquoise belief system views the world as a single living organism and values life as a whole (not only human life). People who value this belief system tend to be conceptual, value learning through experience, and search for meaning and purpose in existence. This search for meaning goes beyond survival, obedience, competition, and peace and reaches spiritual levels. This level of thinking is globalistic, extending across politics, religion, and vested interests. People who value this belief system have more of a community orientation, but they see community as the whole earth with all life in it and they tend to have more of a holistic view of issues or problems.

According to this model, there is a hierarchy among these developmental levels of belief systems (beige level being the simplest, turquoise level being the most complex) in terms of conceptualizing the world. However, this hierarchy is not related to intelligence; in other words a person who values a less complex belief system can be more intelligent than one who values a more complex belief system. People may move from one level to another as their life conditions change to match their belief systems with the conditions of the external world. Growing up, changes in life conditions, important life events, and education are some of the causes that may catalyze movements across these levels. Another assertion of this model is that the purple, blue, green, and turquoise belief systems are more community oriented, in other words, interests of the community is more important than interests of self. On the other hand red, orange, and yellow belief systems are more self oriented, in other words the interests of self is more valued than the interests of community.

The developmental levels in Grave's model do not represent types of people; rather they represent belief systems in people. These levels and the belief systems they represent are influenced by the environment and hence no level is inherently better or worse than another. It is possible to move from a more complex level of thinking to a simpler one if life conditions necessitate such move. If people's life conditions remain constant, their beliefs and hence worldviews may not change much. When people start valuing more complex belief systems across the levels, the previous belief systems are not forgotten and therefore worldviews become larger and more complex. In time, beliefs associated with a past level may be less valued and a person may have values in more than one level as they pass through transitional states. However, generally the belief system of one of the levels tends to be dominant in a person's worldview.

Back and Cowan (1996) warn that this model is not as simple as it seems. This model does not propose that people can be described by one of the levels. These levels just show the peak states of humans' psychological development and many people's worldview may be characterized by more than one of these levels (perhaps one level being the dominant belief system). Many people spend long time and energy in transitional states as they are challenged by changing life conditions and face new ways of thinking. Therefore as one level of thinking is left behind new ways of thinking and beliefs may be activated depending on how perception of life conditions change and the coping mechanisms these conditions necessitate for dealing with these conditions. Graves (2001) suggest that if a person's worldview is in conflict with the reality he lives in, than he may move beyond his worldview and adopt different beliefs that will allow him to deal with the realities that surround him to reduce the possible stress he may feel otherwise. It is also possible that if a person is not open to change, radicalization within a certain level may also happen.

Grave's students Beck and Cowan (1996) continue to use and develop Grave's theory for understanding people's worldviews and ways of thinking and through this understanding they develop models of how change may occur within humans' worldviews. Their efforts made this theory more widely used and discussed.

So What Is Worldview?

Based on my review of the literature it seems like worldview can be defined as a belief system that is unique for each individual. Beliefs that are central to a person's life organize to form the worldview of every person. The beliefs that form the worldview provide meaning for life, means to cope with life conditions and problems, and provide a guide for action. Beliefs within a worldview may be acquired in the form of knowledge through family, culture, social interactions, religion, or education and they may become more rigid and resistant to change in time, as more feelings, emotions, or judgments are attached to them. Worldviews may change as life conditions change or conflicts between the worldview and the external world arise or people may consciously choose to explore their beliefs and become familiar with other belief systems and worldviews and decide to change.

Each way of looking at worldviews provides a different perspective on different aspects of worldviews. The descriptions of worldviews presented above seem to agree that,

- Worldviews are coherent and logical structures of beliefs
- Worldviews provide a framework of how the world is perceived and how to live in this world
- Worldviews have internal and external consistency
- Worldviews may change through time based on external or internal influences
- Worldviews are complex but understandable constructs

I find the following analogy useful in understanding the relationship between belief, worldview, and culture: “If worldview is the tree, beliefs are the branches and the forest is culture” (Yalaki, 2004, p. 30). In this analogy, one can see that beliefs come together to make up the worldview. The more central a belief is, the bigger and central a branch it represents in a tree. However, the relationship between worldview and culture is more complex. Within a forest one expects to see similar trees, however, none of the trees are exactly same with one another. In other words, within a culture one expects to see similarities among worldviews, however, none of the worldviews are exactly the same. It is possible that there may be people who have completely different worldviews but live in the same culture.

In brief, the rationale for this study was that investigating people’s beliefs from a worldview perspective is a more holistic approach for research. As I mentioned earlier, there are many studies in the science education literature about teacher beliefs, but most of these studies focus on certain beliefs about education, students, teaching and learning, schooling, or other specific issues. As Pajares (1992) argue, teachers have other beliefs outside their professions that influence their actions. The worldview concept could be used to capture a bigger perspective of teachers’ beliefs.

Research Questions

The focus for this study was about exploring how the worldview concept may contribute to research about teacher beliefs. Specifically the research questions of this study were:

1. How can teachers’ worldviews be characterized?
2. How are teachers’ beliefs about educational issues related to their worldviews?
3. How are teachers’ worldviews related to their practices?
4. How or under what conditions do science teachers modify their worldviews?

Research Setting and Methodology

This study was conducted as a dissertation research. The research sites for this study were two middle and two high schools in the southeastern United States. The research participants were four science teachers of American origin (three females and one male) teaching in these schools. Their names were Suzan, Sara, Aylin, and Brian (all pseudonyms). The participating teachers had varying degrees of teaching experience and different teaching styles, which increased the diversity of data collected. This diversity was necessary to observe the influence of different worldviews on different practices. The number of participants chosen for this study was balanced by the need for multiple participants to have variety in data, limited hours of the school days, and the need for prolonged engagement with each teacher to obtain the necessary amount of data.

Worldviews are belief systems that influence people’s behaviors and actions. Because of this, studying worldviews is possible through studying peoples’ beliefs and that is possible by talking to them, observing their actions, and making inferences from this data. Therefore qualitative research methodology was more suitable for this study. I adapted the methodology proposed by Guba & Lincoln (1989) in this research for data collection. Guba & Lincoln suggest a hermeneutic dialectic circle as a method for the purposes of evaluation and inquiry, which is a process based on constructivist philosophy. In this process, initially knowledge is constructed through interpretation during the first contact with one of the research subjects. Then this interpretation is negotiated with another research subject, which leads to the modification of the first constructed knowledge. Guba & Lincoln explain that, “This process

is repeated with new respondents being added until the information being received either becomes redundant or falls into two or more constructions that remain at odds in some way” (Guba & Lincoln, 1989, p. 152).

In this study, the hermeneutic dialectic circle was used to ensure participants’ agreement about the research findings about their beliefs rather than reaching a consensus among the participants. This method empowered the participants by allowing them to contribute their input to the research findings. Specifically in this study, I wrote a case study for each teacher based on my observations and interviews with them. I provided the opportunity to the teachers to read the case studies written about them. This allowed them to respond to my interpretations and assertions about their beliefs and practices. This way, I tried to reach an agreement between my interpretations of the participants’ beliefs and practices and their perceptions of their own beliefs and practices. Throughout this process, I tried to have as much dialog as I could with the participating teachers in the form of casual talks or interviews to better understand their beliefs. I asked them questions based on my observations and my casual dialogs with them. The interviews and dialogs generated further questions that contributed to the construction of meaning in the hermeneutic dialectic process with each teacher.

In this study, the data collection methods I used were open-ended interviews, classroom observations, casual dialogs, and a questionnaire about peoples’ beliefs called the Values Test (Beck and Cowan, 2000). The Values Test is designed to provide information about people’s worldviews based on the developmental levels suggested by Clare Graves (1981) and Beck & Cowan (1996). It includes 20 items and each item has seven choices representing each of the belief system of the developmental levels in Grave’s model. In the Values Test, 10 items are asked with a positive question root representing acceptance scores and the same 10 items are asked again with a negative question root representing rejection scores for each of the seven belief systems. 15 points are distributed to the choices for each question and at the end of the test addition of the rejection scores and acceptance scores for each developmental level provides the results. The Values Test provides some information about a person’s worldview; however, it is not used by itself. Beck & Cowan (2000) suggest that Values Test should be used as a conversation starter in interviews in order to start a dialogue with participants about their responses and the reasons for their choices.

This is how Values Test was used in this study. The participating teachers took the Values Test two times with an eight months interval to check for consistency of the results and also through an interview they were asked to comment on their scoring, the changes in their scoring, and the reasons for those changes. The observation part of this research was completed during the Spring 2003 semester. Interviews and conversations with teachers (through meetings and e-mails) continued until early 2004. In the interviews, I asked the participating teachers questions about their beliefs in relation to purpose of education, teaching and learning, teachers’ and students’ roles in the teaching and learning process, assessment, science, school context, challenges, frustrations, and conflicts that they face. The interviews about the Values Test provided information about their more general beliefs and worldviews. Observations were recorded in the form of written notes and expanded and typed later as field notes and interviews were audio taped and transcribed.

The interviews and the Values Test provided an understanding of the participants’ worldviews based on Graves’ (1981) and Beck & Cowan’s (1996) model of developmental levels. I compared these data with the observation data of teachers’ teaching practices. This comparison helped me to construct an understanding of the relationship between the teachers’ worldviews and their practices. I tried to learn how the participants dealt with the conflicts between their beliefs and their life conditions.

After collecting the data, I used data analysis procedures suggested by Bogdan and Biklen (1998) and Miles and Huberman (1994). A common procedure of data analysis suggested by these authors is developing coding categories. After the data was coded based on suggestions from Bogdan and Biklen (1998) and Miles and Huberman (1994), I organized the data based on the established coding categories. In this study, the previous studies about teacher beliefs in the literature helped me determine some of the coding categories during data analysis. I used these categories to organize the data and eventually to write the findings based on the emerging organization of data.

Findings

Because of the research methodology of this study, the findings should involve thick descriptions for each of the participating teachers. However, because of space limitations, findings reported here is more limited. Findings are reported for each participant in the form of assertions in this paper.

The results of the Values Test (shown in Table 1) showed great deal of consistency in participants' responses both in terms of the complimentary results of the acceptance and rejection scores and also in terms of taking the test two times with eight months time interval. However' there were some changes in some responses between the first and second time the questionnaire was taken for which possible reasons are discussed in the conclusions section.

Table 1. Values Test results for each participant based on the points they distributed for each level. The first numbers are the results of the questionnaire when it was taken for the first time while the second numbers are the results of the questionnaire when it was taken for the second time.

		Purple	Red	Blue	Orange	Green	Yellow	Turquoise
Suzan	Acceptance	9-7	0-3	0-0	8-14	32-39	28-26	73-61
	Rejection	6-26	72-36	29-47	18-23	6-10	14-8	5-0
Sara	Acceptance	14-15	6-2	21-11	11-20	45-55	18-24	25-23
	Rejection	21-10	61-64	21-36	22-18	0-0	10-6	15-16
Aylin	Acceptance	0-3	3-7	0-0	4-7	36-23	69-58	38-52
	Rejection	42-35	30-34	45-34	27-24	0-13	4-6	2-4
Brian	Acceptance	9-0	7-2	56-54	21-28	33-37	15-14	9-15
	Rejection	48-62	50-34	0-0	0-7	0-0	7-5	45-42

ASSERTIONS ABOUT SUZAN

Suzan was teaching chemistry at a high school with an upper middle class student population. She had 18 years of experience when this study was conducted. She also held National Board of Professional Teaching Certification and had a doctoral degree in science education. The interviews and observations showed that Suzan is a very confident person and her confidence in herself as a teacher reflects her worldview. The results of the Values Test showed that Suzan values the turquoise belief system more than others. Her acceptance score for the green belief system is also high while her rejection score for the red and blue belief systems are highest compared to other beliefs systems (Table 1). Suzan's dominantly turquoise worldview is also an indication that she is a confident and highly developed person in terms her perspective of the world and the coping mechanisms she utilize to deal with her life problems. Her level of experience in her job and academic status may have contributed to

her confidence as a teacher. Suzan values learning through experience, looking at issues from broader perspectives, and searching for meaning and purpose in life. For example, she sees herself as a learner and despite her advanced degree, awards, and years of experience, she never gives up trying to learn from others and from her students and she often engages in intuitive data gathering. She tries to understand how her students make sense of science and she tries to explore different ways to help them learn through discussions. She is open to outside input and opinions of others about her teaching and methods she use. During her participation in this research, her attitude was actively seeking criticism of her practice from me, which reflected in her question, "When do I get to learn?" She wanted this study to help her learn and improve her practice; an attitude conforms to her values in the turquoise belief system.

Suzan's beliefs about the purpose of education and her practices associated with this belief also reflect her values in the turquoise belief system. She believes that education is an opportunity for intellectual growth rather than a task to be done and this broad perspective about education guides her teaching. However, this was not how she thought in her early career. She said in an interview'

I think it would have been a more valuable experience if I realized that public education is an opportunity and we should be very grateful, thankful for that, that our culture is saying, 'here is an opportunity to learn and grow intellectually' and in this case socially. Instead I saw it more as a task to be done and didn't engage as meaningful as I could. So my biggest challenge is to get [students] - even though this is about grades and they are going to put your GPA's up in ranking and all that - get them beyond it. (Interview with Suzan, 6-5-2003)

Suzan believes that intellectual growth happens through learning and open discussions in which people freely communicate ideas. She also believes that for better learning, students need to experience knowledge in multiple ways and practice it and they need to be active and take responsibility in their learning. In her practice Suzan emphasizes the notions of "learning based on understanding rather than memorizing" and "learning how to learn" more than the science content. She does so with the methods she uses and the way she utilizes assessment. For example, she rarely answers her students' questions directly; rather she asks them many questions back to stimulate them to find their own answers. In this manner, she stresses the process of reasoning rather than the facts. She uses a variety of methods, such as hands-on activities, projects, discussions, classroom presentations, and peer teaching to allow her students to experience knowledge in multiple ways. Suzan sees herself as a co-learner with her students rather than the source of knowledge. She listens to her students' ideas about solving problems and when she deals with a subject that she is not sure about, it does not bother her trying to figure out solutions with her students. Sometimes she acts like a tutor in her classroom and helps her students individually and discusses and shares ideas with them. In her teaching, what Suzan expects from her students is just to accept the challenge of learning and take action. She said in an interview'

I believe that people - in order to learn something - need to experience it in multiple ways and they need to reinforce it and it has to be practical. So I design my classroom experiences where they are engaging, where it gets their attention, where it may generate an interest and then I give them enough of a hands-on, minds-on kind of experience that they can stay with you along the way and then they have to build a practice and check themselves. So we do a lot of practicing and checking after I have got them where they should be on their own. But the bottom line is, I see my job as

plainly responsibility for the learning, helping them develop responsibility for learning. (Interview with Suzan, 2-20-2003)

Learning is so important for Suzan that when I asked her what she enjoyed the most in her teaching, she replied,

Playing with people's way of making sense, when the students allow me to engage with their sense making, when they have developed the confidence to express themselves to the point that we can have an intellectual conversation, debate the way we view it and have a conversation about it. I like that because it gives me access to their way of thinking and I find that exciting. (Interview with Suzan)

When it comes to assessment, Suzan believes that the purpose should be learning not ranking students. So she uses assessment as a way for students to assess their own learning rather than as a value judgment. She lets her students check their own homework and ask for help if they need, which is also a way for her to give more responsibility to the students in their learning. She wants her students to understand that the purpose of assessment is to understand their weaknesses and strengths in their knowledge and to do so she sometimes lets her students grade their assignments and tests themselves. To emphasize learning over grades, she improves her students' grades if they write a report to show her that they learned whatever they missed in a test. In this sense, Suzan incorporates a formative component in the way she utilizes assessment. Cowie and Bell define formative assessment as, "...the process used by teachers and students to recognize and respond to student learning in order to enhance that learning, during the learning" (Cowie and Bell, 1999, p. 101). This is what Suzan does in her teaching, trying to enhance her students learning as they are learning. Black and Wiliam (1998) argue that this way of using assessment improves student learning significantly and they see formative assessment as a key for the reform efforts in education to succeed.

Another reflection of the turquoise belief system in Suzan's attitudes is the fact that she contributes to the field of science education and the community of science teachers by participating in research projects that involve in-service training for teachers. She tries to help science teachers grow intellectually, understand their powers, and be exposed to new ideas that may help them in their teaching. In a way, Suzan tries to improve science teacher education and in turn improve science education itself. This attitude of taking action to change the community that she is a part of is a characteristic of the turquoise belief system.

Suzan also values the green belief system, which prioritize human needs and community relations. Her practice in her classroom reflects this since she is attentive to her students' needs and she respects their ideas. For example, she creates a classroom environment in which her students feel comfortable by allowing them to do whatever they want to do (i.e. bring food to the classroom, leave the classroom for few minutes if they need to, etc.) as long as they act maturely. During classroom discussions, she respects her students' ideas and listens to them carefully and she expects her students to do the same thing for others. She communicates with her students about what they should do or what actions they need to take to learn and advance in her classes. Suzan's students are generally high-level AP and honors students, which seemed to make it easier for her in structuring her classroom environment they way she wants.

Suzan's rejection scores were concentrated mainly on the red and blue belief systems, even though her distribution of scores for these belief systems changed between the two times she took the test. Suzan respects other people's beliefs; however, she expects the same from others. She values communication of ideas without anyone getting offended, if others do not share their beliefs. During our conversations and interviews, she expressed discomfort with

people who want others to believe and act the way they do and even attack or offend others for having different beliefs. This attitude of Suzan was reflected in her rejection scores of the authoritarian blue belief system in the Values Test. About this issue, she said in an interview,

What I am trying to say is that the problem I had with closed minded people or people who believe they are righteous in what they do and they get strength from that, more power to them, but when they use that to put other people down - if you make your own religion, country, anything better by putting somebody down I have a real problem with it. (Interview with Suzan, 11-16-2003)

Suzan's main complaint about her job was the bureaucracy in her school and frequent interruptions in her classes for various reasons. This complaint also complemented her rejection scores for the blue belief system, which value bureaucracy. Suzan also highly rejects the red belief system since this belief system represents an egocentric and power seeking worldview. However, her rejection scores for this worldview diminished over time for which the possible reasons are explained later in this paper.

ASSERTIONS ABOUT SARA

Sara was teaching science to sixth, seventh, and eighth grades at a middle school with a student population of a lower and middle class socioeconomic status. After getting a Master's degree in science education, Sara started teaching in her school and she had three years of experience at the time this study was conducted. Prior to her graduate studies, she taught as an outdoor education teacher in private educational programs. Sara had the least amount of experience among the participating teachers.

Values Test results showed that Sara mostly values the green belief system and she also values the turquoise and yellow belief systems in her worldview (Table 1). Sara and Suzan share some similar values in their worldviews and their beliefs about education and teaching and learning show some similarities. For example, similar to Suzan, Sara thinks that education is about personal development of students. She believes that the purpose of education is empowering students by helping them learn new knowledge and new skills so that they can have more options in their lives. Sara also believes that students should be active and take responsibility in their learning.

When compared to Suzan, Sara does not have the same confidence about her job. Teaching is not exactly what she had in mind and she is not quite sure what causes dissatisfaction in her job. She said several times during our interviews "something is missing" in her job that makes her feel this way. There seem to be a mismatch between the ideal teaching context she dreamed about and the real context she teaches in, which creates conflicts and stress for her. She expressed her feelings as,

I wish I had been a teacher before I have started the Masters program. All the theory and philosophy, I would have taken it in differently. I remember in our classes when we got to write up our opinion on the web site and I was always saying "To those of you who are teachers, if you think I am so off base, tell me, let me know because I don't know. I don't know what it is like out there in the classroom" and nobody ever really said a lot about that to me like "Be careful because you are dreaming really big." (Interview with Sara, 3-3-2003)

Sara seems to think a lot about the reasons for some of her students' less than ideal academic achievement in standardized tests. She asks questions like,

Are all these hands-on [activities] that we do in [my middle school] a waste of time? Should we care that these kids do not score as high as [Uptown Middle School (pseudonym)]? Does it have anything to do with hands-on versus bookwork? Is it just socioeconomics? (Interview with Sara, 12-16-2003)

Sara blames herself in some of the situations in which she does not get desired results in terms of student success. She sets high standards for herself to reach the ideals in her mind and not being able to meet those ideals all the time causes stress for her. She also recognizes that the accountability for standardized tests and additional responsibilities that she has in her school other than teaching cause additional stress. Sara has less teaching experience and lower confidence in her content knowledge compared to Suzan, which seems to be one of the reasons for the stress and conflicts she feels. While Suzan has figured out how to deal with the conflicts and challenges she faces, Sara still struggles with figuring out how to do just that. What is common between Sara and Suzan is that they both feel the responsibility of teaching within themselves; however, they differ in how to deal with the problems they face.

Sara's beliefs influence her practices and the methods she uses just like Suzan. Having values in the turquoise belief system, Sara keeps a broad perspective about the purpose of education that helps her focus her goals as a science teacher. She sees teaching science (or any other subject) as a canvas for achieving the broader purpose of education that she believes in, which is "empowering students." She wants her students to be empowered by learning science, which means having more choices in their lives thanks to their knowledge in science. For example, as they go on with their education, Sara wants her students to be able to use their science knowledge to advance and achieve their goals. Another reflection of Sara's values in the turquoise belief system is that she values learning based on understanding rather than memorizing. Similar to Suzan, Sara thinks that learning is the responsibility of students and she sees her role as to help students and be a guide to them in their learning. She wants to find and nurture students' interests so that they keep being interested in learning science. She believes that students learn best when they feel responsible for what they are doing and when they are active. This is why she uses hands-on activities very often in her classes. She thinks that hands-on activities are the best way to make students feel responsible and be active in their learning. Sara also emphasizes learning in the way she uses assessment in her teaching. For example, when many students do not get good grades in a test, she re-teaches that subject until her students' learning is improved. This is a way of incorporating formative aspects in the way she uses assessment. She does not want assessment to be a punishment for her students.

One difference between Sara and Suzan is that, in all the activities and methods she uses, Sara wants to be the perfect guide for her students and be able to answer all of their questions. She uses the analogy of a "well oiled machine" to describe the type of activities she wants to do in her classes in which she can control everything easily. However, not being able to do so makes her feel that she is weak in her science content knowledge. The standardized tests and state mandates require her to teach a large amount of content and she feels like she does not have enough time to cover everything properly. This situation creates conflicts and stress for Sara. She also has a tendency to internalize blame when her students' academic achievement is less than ideal, which result in more stress. She focuses on what she might have done wrong when her students do not get good grades in tests and the way she uses assessment reflect this internal focus of responsibility (i.e. re-teaching until their grades are improved). Sara's personality and her views about the student context in her school also influence her attitudes in her teaching. She explained that many students in her school have had bad experiences with schooling in the past and she sees her role as to provide a more

caring and accepting environment for them. With her passion and caring, Sara sets high standards for herself, but the state policies do not seem to be helpful to Sara in her desire to achieve those standards. In contrast, Suzan is comfortable in assuming the role of a co-learner with her students and discuss with them content that she is not sure about. She does not worry about knowing everything since she sees herself as a learner. Suzan takes the issue of responsibility seriously and when her students act irresponsibly or do not study, she is more comfortable with allowing them to suffer the consequences rather than blaming herself (unlike Sara). However, it is also important to keep in mind that the student population Suzan has is different than Sara's students.

Sara cares about her students and their feelings very much, which is an attitude common among people who value the green belief system. She is very attentive to her students' feelings and emotions and she is a very emotional person herself. She tries to create an environment in her classroom in which her students feel safe and comfortable. She is a successful teacher in making her classes fun and enjoyable where her students can freely express their opinions. She uses classroom discussions often in her teaching and in these discussions she respects her students' views and listens to them even if they sound odd.

Similar to Suzan, Sara also respects other peoples' beliefs; however, She feels uncomfortable in dealing with people who try to force others to believe in a certain way or who offend others because of the beliefs they hold. This feeling reflects in Sara's rejection scores for the blue belief system. Those who adamantly promote their religious beliefs especially bother her. She explained that she is in search of spirituality in her life and she does not have strong religious beliefs. She explained in an interview,

One right way, all that stands out to me is my recent discussion with a colleague, this fundamentalist, who told me I was going to hell and so the [idea of] one right way automatically brings me to that discussion of her telling me that there is only one right religion and one right faith. I am having a very hard time with it. I wish we hadn't had the discussion, but I think it kind of affected my opinion about her as a person and I really kind of distanced myself from her for about two weeks and now I am getting over that but I think about it a lot, about that discussion. (Interview with Sara, 12-16-2003)

Sara's rejection of the blue belief system is almost as high as Suzan's and similar to Suzan Sara also rejects the red belief system.

ASSERTIONS ABOUT AYLIN

Aylin had nine years of teaching experience when this study was conducted. She teaches science, math, and geography to sixth graders at a middle school in the southeastern United States. When I observed Aylin's classes, it was her first year of teaching science and she was teaching out of field at the time. She explained that she held a Master's degree in social studies education and an Educational Specialist degree in Exceptional Education, but she did not have certification for science. Aylin was originally hired to be an Exceptional Student Education (ESE) teacher. After teaching in this critical needs area for several years, she requested to teach regular students. The only way for her to teach regular students was to agree to teach science. By the time I started observing her classes, Aylin had applied for certification for teaching integrated curriculum that would allow her to be considered infield for teaching math, science, social studies, reading, and geography.

Aylin's worldview is dominated by her values in the yellow and turquoise belief systems and -to some extent- the green belief system (Table 1). Her rejection points are

concentrated on blue, purple, red, and orange belief systems. Aylin has high confidence in her teaching and this is reflected in her desire not to have interference from anyone in her teaching. She wants to have complete control in deciding what to teach or what to do in her classes, especially for teaching social science. However, when it comes to teaching science, she is more open to suggestions or help from outside due to her lower confidence in her science content knowledge. She feels like she does not have the content knowledge she needs to guide her students in science as much as she can in social science. She explained her feelings about teaching science in an interview,

I had to get over some “Oh am I doing students a good service by teaching science? Will I be too much of a learner that I actually get in the way, that the students will not be further along than me?” You know, “Am I going to impede them in any way and their progress because I am not where they are?” Then I subordinate... (Interview with Aylin, 3-9-2003)

Aylin’s self-confidence is reflected in her values in the yellow belief system. Unlike Sara, Aylin does not feel too much stress for her low level of science content knowledge, which may be the result of her high self-confidence. Another reflection of Aylin’s values in the yellow belief system is her frustration with the education system she works in. People who value the yellow belief system become frustrated if they think the system they work in is inefficient. This is how Aylin feels about standardized tests, accountability, and her school’s demand for doing a lot of paperwork to show that she follows the required policies and procedures in her teaching. Even though she sometimes gets very frustrated with the school policies and procedures, she has a positive attitude towards the realities of the world around her. For example, when I asked her, “How do you deal with the challenges you face?” she answered,

I laugh about them, but I don’t know if that always works. I just see what I can learn from it. Because really, whenever you feel frustrated or upset it is because you are desiring something that you are not getting and so if you can let go of that preconceived notion of what should be, you won’t feel that way quite as much. (Interview with Aylin, 5-19-2003)

This means, Aylin is willing to accept the outside world as it is, even if she feels uncomfortable with some aspects of it. In contrast, Sara internalizes the problems she faces and thus has more stress when she faces with conflicts and challenges in her job.

As a reflection of her values in the turquoise belief system, Aylin also has a broad perspective about the purpose of education. She has similar beliefs about education and teaching and learning to Suzan and Sara. She believes that the purpose of education is to provide the skills and knowledge students need to pursue their passions in life and she also believes that education is about personal development. Similar to Suzan and Sara, this perspective about education guides Aylin’s teaching. However, her teaching practices are different compared to Suzan and Sara. For example, Aylin rarely uses hands-on activities because she does not want to go into activities in which she does not feel confident in guiding her students due to her low confidence in her science content knowledge. She uses classroom discussions often in her teaching and emphasizes social aspects of science and its relevance to life. She explained that her social science background may be influencing the way she teaches science.

Aylin agrees to Suzan and Sara that students should take responsibility in their learning. To help them understand their responsibility, she teaches them how to behave and

what are the consequences of misbehavior. She sees her role as a teacher as to model learning for her students; in other words she tries to teach them how to learn regardless of the subject she teaches. However, she is worried that in science (and mathematics) she may become too much of a learner and get into the way of her students' learning because of her low level of content knowledge. In this sense she is comfortable with assuming the role of a co-learner; however, she thinks that teachers need to have a certain amount of content knowledge in order to guide their students. Similar to her beliefs about the roles of teachers in teaching and learning, Aylin believes that ideally schools should provide a model for students for the real life that they will face after completing their formal education by giving them more responsibility for their actions and allowing them to face the consequences of their actions. However, she thinks that students' behaviors are controlled by the adults to protect them and schools become places that do not simulate the real life. She had this to say about this issue,

You know, ideally the classroom would be just like the real world. Because that is where they are going to be, and at schools it's like we alter the [reality]. It's like the Truman Show, we are altering the reality and then they graduate and we just toss them out there (Interview with Aylin, 5-19-2003)

Aylin's beliefs about the ideal role of schools in education indicate her long-range thinking about this issue, which is a characteristic of the yellow belief system. Aylin's belief about the roles of teachers in teaching and learning is also parallel to her beliefs about assessment. She believes that assessment is a way for her to see if she is doing a good job in her teaching. This view about assessment is similar to Suzan and Sara in terms of internalizing the responsibility of teaching. However, she admits that she does not always use assessment this way because of the pressure coming from parents. Parents want to see grades for their kids and therefore the way Aylin uses assessment ends up being more summative than formative.

Aylin believes that part of her role as a teacher is to nurture her students. She tries to provide a safe environment for her students, where they can questions, make mistakes, and feel accepted. During class discussions, she creates scenarios to which students can respond and express their opinions freely. She values every student's opinion even if they sound odd. Similar to Suzan, she is also successful in communicating with her students about what responsibilities they have and how should they behave in her classes. These attitudes are reflected in Aylin's values in the green belief system. However, her acceptance of this belief system decreased in time because of the changes in her thinking about the values of this belief system the reasons for which are explained later in this paper. Similar to Suzan and Sara, Aylin mostly rejects the blue, purple and red belief systems.

ASSERTIONS ABOUT BRIAN

Brian had taught all sciences, including biology, chemistry, and physics to grades ranging from 9 to 12 and he had certification in all the areas he taught when he participated in this study. During this study he was teaching integrated science to ninth grades. Brian was a very active member of the teachers union and served on many committees associated with science teaching such as the local science fair. Brian was also the chair of the science department in his high school. He had 26 years of teaching experience and had an Education Specialist degree in science education. Brian was the most experienced teacher among the teachers who participated in this study.

Values Test results showed that Brian values the blue belief system more than the other belief systems in his worldview (Table 1). He also values the green belief system while

rejecting the red, purple, and turquoise belief systems. In this sense, Brian's values and beliefs seem to be different than the other three teachers. He describes himself as a religious and conservative person and he bases all his beliefs on these two values, which is a characteristic of the blue belief system. He explained in an interview,

A firm Christian believes and [it is] a key part of my life so any belief or value is going to be have to be centered on that. I don't think that we are necessarily ordained or destined to be a certain way ... There is a power within you to shape tomorrow even within the idea of a firm foundation, the Lord works within your life to do that. (Interview with Brian, 1-7-2004)

Having a dominantly blue worldview means that he values loyalty, respect for authority, traditions and community relations. This reflects in his beliefs about education and the educational system he works in. For example, Brian did not express negative feelings about the education system he works in during our interviews. He believes that standardized testing and teacher accountability should be part of today's education system. He also believes that teachers should be held accountable for their teaching. Standardized testing and accountability are policies that originate from blue thinking because of the authoritarian attitude implied in these policies and the consequences imposed on schools and teachers. Therefore, the fact that Brian agrees with these policies of the educational system is consistent with his dominantly blue worldview. This is why he does not feel the stress and frustration with the policies of the education system unlike Sara and Aylin.

Similar to other three teachers Brian agrees that the purpose of education involves personal development of students; however, he also thinks that the purpose of the education also involves preparing the future citizens and the job force that the society needs. This is a belief that is not expressed by the other three teachers, and it is consistent with Brian's values in the blue belief system. Brian also believes that education starts as the responsibility of the state and at a certain stage it becomes the responsibility of students. During our interviews, Brian argued that many students do not realize this responsibility and expect continuous adult supervision in their education. He expects students to share the responsibility of learning with the teacher and take initiatives in their learning process. He said in an interview,

I want you to be aware of the fact that I am not negating my responsibility, [when I say students need to be more responsible in the teaching and learning process]. I am saying meet me somewhere along the way, whether it is a third of the road, or half of the road would be more ideal, but meet me somewhere where I can see where you are in terms of this process. When a student sits back, I guess my biggest example of this would be when they say, "I don't understand anything." How can you not understand anything and be in a classroom? You have to understand something so where can I begin this construction of knowledge with you if you are going to say I don't understand anything. And so to me that is irresponsible. (Interview with Brian, 1-7-2004)

Other teachers believe that most of the responsibility for learning lies with students and the role of the teachers is to help with their learning. Whereas Brian splits that responsibility more equally between teachers and students by saying "I expect them to meet me maybe not all the time half way, but at least part of the way" (Interview with Brian, 1-7-2004). What Brian means by this is that students should take common responsibilities, such as, do homework, come to class prepared, and participate in class activities. Similar to Brian, Suzan also believes that students should be responsible for their learning; however, in contrast

to Brian, she uses methods to help her students to understand their responsibility whereas Brian simply expects it. She puts more emphasis on modifying the strategies she uses for teaching with the knowledge she gathers about her students' learning and their way of making sense. Aylin also shares the belief that students should be responsible in their learning and similar to Suzan she is successful in teaching this responsibility to her students in the form of classroom rules. Sara also believes that students should be responsible in their learning; however, she blames herself when her students' perform less than ideal in academic tests. In brief, I argue that Suzan and Aylin have more sophisticated approaches in helping their students understand their roles and responsibilities, which is consistent with their worldviews.

Another difference between Brian's and other teachers' beliefs is the way Brian sees his role as a teacher. He uses the "coach" metaphor to describe the ideal role of a teacher, which implies that the teacher presents the strategies and knowledge to the students and students should do their part to be successful. When I asked him to explain this metaphor in an interview, he said,

Well this really leans heavily back to the whole deal about personal responsibility. So when a student recognizes that they need help in this area, I as a coach or as a supporter, present the key concepts as in the case of a coach. "This is the game plan, this is what we are trying to do, know what are the things that you can do already, what are the things that you need?" Helping one shooting the jump shot in basketball or balancing equations in chemistry. Recognize where your strengths are, recognize where your weaknesses are and then be willing to seek help, that's another aspect of coaching! The idea is to seek help and if you know you need help then I am there to help you. I offer help all the time. (Interview with Brian, 5-1-03)

Even though coaching is the ideal metaphor for teachers' role, in his practice Brian mainly uses lecturing and not many hands-on activities. He cites the unavailable resources in his school and safety concerns as the reasons for not being able to do hands-on activities often. He criticizes teachers who do hands-on activities and experiments in school facilities that have incomplete safety equipment. This shows that Brian values the notion of going by the book in his practices, which is another attitude consistent with his dominantly blue worldview.

When it comes to the purpose of teaching and learning science, one of the main differences between Brian's beliefs and the other teachers is his emphasis on content. According to Brian, the purpose of teaching and learning science is to achieve scientific literacy in science. Brian wants his students to understand science so that they can make informed decisions about science related issues that affect them or their society. He wants his students to have opinions about environmental and other popular science related issues, and he often refers his students to the newspaper articles about science for this purpose. In contrast, Suzan thinks that learning the content is a natural consequence of developing a responsibility for learning. Aylin and Sara's views on this issue are closer to Suzan's view. The way Brian uses assessment is parallel to his emphasis on content in his teaching. He uses a system in which most assignments or tests he gives to his students worth a point that counts toward a total, which determines students' final grades, which is a summative form of assessment. Teaching methods Brian uses and his beliefs about the purpose of science education are parallel to the way he uses assessment and compatible with his values in his worldview.

Besides the blue belief system, Brian also values the green belief system. His values in the green belief system are reflected in the responsibilities he takes. For example, he takes charge in the administration of a teacher union organization and also local science fair events.

During one of our interviews, Brian explained that he does not agree with all aspects of the teacher union organization that he works for; however, he values the idea that everyone should have a chance to express their opinions and be heard. This belief also conforms to Brian's values in the green belief system. He explained that unions are associated with liberal thinking, but he sees himself more of a conservative person, which shows that his values in the blue belief system are more important to him. He explained this in an interview,

Well, the union activity has been important but it is something that kind of fell in my lap and I ran with it to a certain degree because there really wasn't anyone else to take up the ball and run with it. ... It has become an important aspect of my life but it is kind of interesting because I hear people talking about unions and there are lots of things about unions that I agree with. The idea that everyone should have a fair chance, everyone should have a fair opportunity to [deal with] injustice or miscarry of justice, but there are some policies of the national union itself that as a southerner I am not real thrilled about. And [in those aspects] I have served a smaller part and said, 'well when it comes to collective bargaining, when it comes to the idea that people need to be represented, I can sort of take the good with the bad.' And so I feel like that is an important aspect of my personality. I am not a strongly liberal person. I think I have some very moderate views and some things probably be considered liberal, but [for] many other issues it would be pretty conservative. And so here I am a union representative and people label you as a certain character with that and that is certainly not my personality. I am strongly religious, which for some reason to be considered liberal it is almost non-religious all of a sudden. (Interview with Brian, 1-7-2004)

When it comes to the negative responses for the purple, red, and turquoise belief systems in the Values Test, Brian said that those beliefs, or ways of thinking, just do not appeal to him.

COMPARISON OF THE FOUR TEACHERS

The above assertions include comparisons of the findings about the four participating teachers. In this section, further comparisons among the participating teachers' beliefs, worldviews and practices are discussed. When one looks at the assertions about each of the participating teachers, it is possible to see the commonalities and differences between their worldviews and beliefs. Comparison of these teachers shows the usefulness of the worldview model in understanding the relations between teachers' worldviews, beliefs, and practices. Teachers who have similar worldviews also have similar beliefs. While the link between worldviews and beliefs is more evident, the influence of worldviews on attitudes and practices are more complex because of the influence of context. When there is a mismatch between the worldviews and context, teachers feel conflicts, frustration, stress, or discontent. The way they deal with these problems is different for each teacher. Starting with the dominant yellow and turquoise worldview levels, people seem to have more confidence in their ability to bring about change around them (Bandura, 1994 calls this self efficacy beliefs) and less fear of the outside world, which is the case for Suzan and Aylin. This seems to be a result of a more developed and sophisticated perception of the world (Beck & Cowan, 1996). People who value the ways of thinking in these levels have more of an internal locus of control in their actions and their concern is the development of the whole system they live in (society, country, humanity, earth, etc.). Sara has an internal locus of control similar to Suzan and Aylin; however, her attitude of blaming herself and not being sure about how to bring about change in her environment seems to be major source of stress in her life. Brian on the other

hand has more of an external locus of control and he tends to hold people around him and work conditions responsible in bringing about change more so than himself.

One example that shows the link between worldview and beliefs is the attitudes of Suzan, Sara, and Aylin regarding the blue belief system. Suzan, Sara, and Aylin have high rejection for the blue belief system while Brian highly accepts it. This creates a difference between Brian's beliefs and values and the other three teachers' beliefs and values. During our interviews, Suzan, Sara, and Aylin expressed discomfort with dealing with people who have a dominantly blue worldview; however, their discomfort is not with the values of the blue belief system per se. They feel uncomfortable with dealing with people who put pressure on others for not sharing their beliefs. They especially reject the idea of "one true way" which is also a characteristic of the blue belief system. This is an indication that the common values in their worldviews have common influences on these teachers' relations with people who mainly value the blue belief system.

Working in an education system that is influenced by the blue belief system's way of thinking with its authoritarian, going by the book, and traditional values creates discomfort for Suzan, Sara, and Aylin since they do not share these values. Suzan is very successful in dealing with her discomfort thanks to her teaching experience and her beliefs. Aylin and to a larger degree Sara feel stress and frustration with the values of the education system that they work in. In contrast, Brian's worldview is compatible with the educational system and he did not express discomfort with it. This is why he does not share many of the frustrations and stress that Sara and Aylin have. Brian's complaints about his job mainly focus on his work environment.

Another example that shows the link between worldviews and beliefs is that all of the teachers value the green belief system to a certain extent (though, Aylin's values for this belief system has decreased over time). This similarity is evident from their beliefs and attitudes. They all respect other people's beliefs as long as their beliefs are not attacked or offended. In their practices Suzan, Sara, and Aylin respect their students' views and opinions and they listen to them with interest during classroom discussions. They try to address their students' needs by creating a safe, comfortable, and enjoyable environment for them. Suzan and Brian are active in the local teacher communities and they try to contribute to these communities with their service. All of these attitudes can be associated to these teachers' values for the green belief system in their worldviews.

The relation between worldviews and teaching practices is more complex. Teachers prioritize their beliefs based on the structure of their worldviews and the influence of their environment. The way they prioritize their beliefs influence their self-confidence and locus of control in their actions. For example, while Suzan is a more experienced and confident teacher, Sara seems unsure about the effectiveness of the methods she uses and she feels more stress within her school context. Suzan on the other hand is not as much bothered with the education system and school policies even though she does not agree with them. She thinks that she has the power to do whatever she wants within any educational system and that every teacher has the same power. Suzan does not have fear in her actions while Sara fears failure in her job. However, it is important to compare Suzan and Sara's teaching contexts when comparing their practices. Suzan's students seem to be more mature and academically high level, which probably makes it easier for Suzan to actualize her beliefs in her practices. Sara's students on the other hand are younger and less mature and they are not academically as high level as Suzan's students. Facing a different teaching context than she imagined forces Sara to prioritize her beliefs in a way that allows her to survive rather than actualize her ideals. Suzan explained that when she has difficult students, to deal with the challenge she organizes her classes to be more structured. Perhaps similar to Sara, Suzan may not be able to realize many of her ideal teaching practices when her students are less mature and at lower academic level.

However, Suzan is able to adapt to her environment and the needs of her students, which shows the sophistication of her belief structures, while Sara is learning to deal with her teaching context.

Another thing that influence teaching practice, besides worldview and beliefs, is the teaching experience and content knowledge. Suzan has almost 20 years of teaching experience and she is a confident teacher in both her content knowledge and her teaching. She explained that it took time for her to increase her confidence in her content knowledge during her career. Suzan still feels that she lacks in her content knowledge, but she developed an attitude of learning with her students rather than feeling bad about it. Sara on the other hand, has much less experience compared to Suzan and she has lower confidence in her content knowledge and her teaching. Aylin has almost 10 years of teaching experience and she is a confident teacher, however she started teaching science only a year before when this study was conducted and she does not feel confident in her science content knowledge. Because of her confidence in her teaching though, Aylin does not feel stressed in her job as much as Sara. Brian has the most teaching experience and he is a confident teacher in both his content knowledge and teaching. However, when Suzan and Brian are compared, their teaching methods and beliefs about educational issues differ because of the differences in their worldviews.

A final comparison of these teachers is about their self-efficacy beliefs and how these beliefs relate to their worldviews. Self-efficacy beliefs is defined by Tschannen-Morana & Hoy (2001) as,

Teacher efficacy is a simple idea with significant implications. A teacher's efficacy belief is a judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated (Armor et al., 1976; Bandura, 1977). This judgment has powerful effects. (Tschannen-Morana & Hoy, 2001, pp. 783)

Based on this definition, it is possible to argue that Suzan and Aylin have stronger self-efficacy beliefs compared to Sara and Brian. Suzan and Aylin have high acceptance points for the turquoise and yellow belief systems. Self-confidence and the feeling of self worth is one of the characteristics of these belief systems. In their practice, both Suzan and Aylin have confidence in themselves to bring about desired changes in their students. On the other hand Sara's acceptance of the turquoise belief system is relatively less compared to Suzan and Aylin and more importantly she is a less experienced teacher. Hence her self-efficacy beliefs are not as strong as Suzan and Aylin. She puts the blame on herself more than anyone else for the problems she is facing. When it comes to Brian, he seems to believe that most of the problems he is facing originate outside of himself (especially from his school environment). In this sense, his self-efficacy beliefs are not as strong as Suzan and Aylin even though he has more experience than they do. This is an attitude common among people who have a dominantly blue worldview.

In brief, teachers' worldviews affect every aspect of their lives. Their beliefs, values, feelings, practices, and relationships are all influenced by their worldviews. Teachers who share similar worldviews have similar beliefs about educational issues. However, their practices are influenced by experience and context as well. Since these teachers' beliefs are based on their worldviews, if they face with conflicts between their beliefs and their experiences, they feel stress and frustration. Based on these conclusions, it is possible to expect that teachers having similar worldviews may also have similar attitudes and practices provided that their contexts and level of experiences are similar as well. The worldview

model seems to offer a holistic perspective of teachers' beliefs and it is a useful tool to understand how their beliefs fit together within a structure.

CHANGES IN WORLDVIEWS

Even though worldviews form in long time periods and are resistant to change, people may modify their worldviews in the face of changing life conditions. Change in teachers' beliefs is desired within the framework of reform efforts in science education. Educating science teachers so that they utilize inquiry in their teaching, understand the notions of learning to learn and becoming life long learners, and use formative methods of assessment more often is the goal of current reform. The worldview model suggested by Graves (1981) and Beck & Cowan (1996) provide a framework for how desired changes may happen in teachers' beliefs through exploring and studying worldviews. While this study did not go into the process of change, Beck and Cowan's framework may be useful for teacher educators. The most important condition Beck & Cowan talk about for change is "potential," which means individuals tendency to change. They categorize people as "open, arrested, or closed" in terms of their potential to change. Based on the findings of this study, I assert that Suzan is the most open participant to change since she seeks change herself. Aylin is also an open person to change, because she is willing to accept the world as it is and try to understand it rather than feel stressed by it. Sara probably fits in the arrested category, which means, she has potential to change but because of the constraints that exist within her context, she does not know how to change. In order for change to happen within Sara's worldview, she needs to resolve her immediate problems by eliminating the barriers she faces. A supervision of a mentor might be useful for Sara to break out of constraints and stress she feels. Perhaps studying the worldview concept may help to get a perspective of how her worldview fits within the school system she works in and this understanding may help her to make decisions about how to eliminate her stress in her life. When it comes to Brian, it seems he fits within the closed category. He believes that most of the problems he faces in his teaching originate from outside of him, which indicates that his potential to change is less than the other three teachers. Beck & Cowan (1996) provide more detailed explanation the dynamics of change within worldviews in their book *Spiral Dynamics*. Based on the framework they provide, I argue that one of the goals of education should be promoting openness to change both for students and teachers.

Change within people's worldviews may happen as a natural consequence of changes in their life conditions or when there is a deliberate attempt to change in order to achieve a more sophisticated understanding of the world and other worldviews and hence achieve harmony. The results of the Values Test provided some insight into what changes have occurred within the participating teachers worldview during an eight-month period. Suzan, Sara, Aylin, and Brian took the Values Test with about eight months interval. When the results of the test scores for each time compared during interviews, it became evident that there was not too much variation. Some of the variations were caused because of random reasons, such as giving the wrong score to the wrong item, misreading a question, or making a momentary judgment about an item that changed later. However, some of the variations seemed to have causes within recent experiences of the teachers. For example for Suzan, the most notable change in her scores is the decreased rejection of the red worldview. To explain this change, she talked about her recent encounter with one of her student's parent about an event that took place in her classroom that involved cheating. Suzan described the parent as rude and egocentric who reflected behaviors of a person with a dominantly red belief system. She said that in the past she would try to argue with this kind of a person trying to convince him of her opinions. She explained that her attitude against this type of people has changed

and rather than falling into the reactive trap the parent was setting up, she responded by saying the student was in her class by choice and that if the parents were uncomfortable they should remove the student and get another teacher. She did not want to argue with the parent because she saw the futility in doing so.

Another notable change in Suzan's scores is her increased rejection of the blue worldview. This is also the most significant change in Sara's scores. Both Suzan and Sara talked about their recent encounters with strongly religious people, before they took the Values Test second time, who criticized them for their beliefs. They both feel very negatively about people who attack or bother others for not sharing similar beliefs with them. Suzan and Sara are open-minded when it comes to religion and they question religious constructs, which is unacceptable within the blue belief system. Both Suzan and Sara explain that they respect other people's beliefs, but they do not share the "one true way, loyalty, respect for authority" kind of thinking of the blue worldview.

In Aylin's scores, the most significant change is the decrease in her acceptance scores for the green belief system and also the increase in her rejection scores for the green belief system. She explained the reason for this difference by explaining how a recent change in her thinking took place about some of the values that are important for the green belief system, such as "equality among humans." She explained that a book that she read recently made her think that the idea of equality for everyone in itself does not grant equal life conditions for every people. People need to take actions and exercise their equal rights so that equality has a meaning. Aylin explained that this change in her thinking made the green worldview less appealing to her because of the lack of emphasis on action in that way of thinking.

For Brian, the main change in his scores is the decreased rejection of the red belief system. During our interview, he explained that the time of the year might have been the reason for the difference in his scoring. He explained that when the first time he took the Values Test, it was a more stressful time for him, when he did not have a classroom of his own and he had to move around the school building for his classes. My interpretation of this is that more stress made it difficult for Brian to deal with students many of whom dominantly operate from the red worldview and his rejection of this belief system was higher. The second time he took the test, he had a classroom of his own and he did not have as much stress and his rejection scores decreased.

In brief, these findings show that environment and life experiences cause changes in people's beliefs. These changes may be temporary or overtime they may become more permanent. These results only show short-term fluctuations in worldviews; however, overall worldviews seem to be robust constructs that do not change easily since they are formed over long periods of time with immeasurable amounts of experience.

Conclusions

In terms of systems engineering, present policy seems to treat the classroom as a *black box*. Certain *inputs* from the outside are fed in or make demands - pupils, teachers, other resources, management rules and requirements, parental anxieties, tests with pressures to score highly, and so on. Some *outputs* follow, hopefully pupils who are more knowledgeable and competent, better test results, teachers who are more or less satisfied, and more or less exhausted. But what is happening inside? How can anyone be sure that a particular set of new inputs will produce better outputs if we don't at least study what happens inside? The answer usually given is that it is up to teachers - they have to make the inside work better. This answer is not good enough for two reasons. First, it is at least possible that some changes in the inputs may be counter-productive - making it harder for teachers to raise standards. Secondly, it seems

strange, even unfair, to leave the most difficult piece of the standards-raising task entirely to teachers. If there are possible ways in which policy makers and others can give direct help and support to the everyday classroom task of achieving better learning, then surely these ways ought to be pursued vigorously. (Black and Wiliam, 1998, pp. 1)

Black and Wiliam (1998) very nicely explain the current status of educational reform. In the United States, *National Science Education Standards* (National Research Council, 1996), *Benchmarks for Science Literacy* (American Association for the Advancement of Sscience, 1993), and *Standards for Science Teacher Preparation* (National Science Teachers Association, 2003) outline suggestions for reform in science education. These suggestions include inquiry based teaching, aiming for scientific-literacy, and encouraging teachers and students to become life-long learners. Science teachers are expected to implement these suggestions in the teaching and learning methods they use. In the United States, a common approach for implementing the reform suggestions has focused on content knowledge through the policy of standardization and accountability. This approach determines the expected outcomes while providing little or no help to teachers and schools, and it holds them accountable for achieving the expected outcomes. Hart (2001) and Pinar (2004) argue that current emphasis on standardization and accountability in education has an adverse affect on teaching and learning in schools. Pinar argues that the standardization and accountability turns teachers into technicians and schools into “skill-and-knowledge” factories. He explains that politicians took control of the curriculum and turned it into an examination driven curricula and educators’ influence on curricula has decreased. Hart agrees by arguing that contemporary education mainly focuses on “downloading facts” and “fostering compliance.”

In light of these discussions, deciding how to realize suggestions for reform is an important issue. Some see teachers as the main agents of implementing reform in science education (Bybee, 1993). As Pinar (2004) argues, educational policies that see teachers as technicians makes it difficult for teachers to realize their roles in educational reform. Therefore, educators should assist teachers to help them examine their beliefs about science teaching and learning in relation to reform suggestions to understand what needs to be done and take action to achieve success in reforming science education. To do so, teachers should be critical and reflective of their practice, which means they should their beliefs and actions in their classroom. Cox-Petersen (2001) and van Zee (1998) explain that teachers become practitioners when they engage in research activities to understand their own practice, their context, and their students. The idea of teachers doing research to improve their practice and their students’ learning is referred to as action research in the literature (Hewson et al., 1999; Kyle, 1997; Tabachnick & Zeichner, 1999). Reflection is a very important aspect of action research. Cox-Petersen argue, “When teachers reflect about their practice, they clarify their thinking, and anticipate decisions and future action” (Cox-Petersen, 2001, p. 107). She goes on to say that reflecting on their practice “encourage teachers to take responsibility for professional growth” and “facilitate teachers’ development of their own philosophy of education” (Cox-Petersen, 2001, p. 107). Tabachnick & Zeichner explain,

A voluminous literature representing work in several countries has consistently reported that teachers who engage in action research generally become more aware of their own practices, of the gaps between their beliefs and practices, and of what their pupils are thinking, feeling, and learning. Research also shows that action research helps sharpen teachers’ reasoning capabilities and facilitates the development of dispositions to self-monitor one’s teaching practice over time (Biott, 1983; Elliott, 1980; Noffke & Zeichner, 1987; Ruddick, 1985; Zeichner, 1993). (Tabachnick &

Zeichner, 1999, pp. 310)

They also argue that for action research to be useful for teachers, they need to share what they learned with others and listen to others' suggestions and ideas and integrate all these into their thinking. Ultimately action needs to be taken based on what is learned as a result of action research and its findings need to be communicated to improve practice and student learning (Tabachnick & Zeichner, 1999). In brief, action research is a way for teachers to be critical and reflective of their beliefs and practice and it allows them to become learners through inquiry and research.

There are of course other tools to help teachers to be reflective about their practice and beliefs, such as autobiographies, journals, and narratives (Cox-Petersen, 2001). Helly (1993) provides a nice example of the usefulness of reflection as a way for improving a science teacher's practice through action research and autobiography. Combined with these available tools, I argue that the worldview model suggested by Graves (1981) and Beck & Cowan (1996) provides an extra perspective and depth for teachers to understand their beliefs and values relative to their social and political context in a process of reflection. Their model also provides a framework of how change occurs within teachers' worldviews and its necessary conditions. This framework can be a guide to educators who want to change teachers' beliefs and practices through the use of reflection.

Among the participants in this study, Suzan provides an excellent example of a teacher who has spent a lot of time reflecting on her practice through many research activities. Her values within her worldview parallel her highly developed understanding of her own practice and goals. She sees herself as a learner, she seeks criticism of her practice from others, she engages in action research to improve her practice and her students' learning, and she is a confident teacher. In a sense, Suzan represents an ideal model of a teacher that the reform efforts in science education strive for. Every teacher thinks about his or her own practice in one-way or another. However, in a reflective process they do so purposefully to study, understand, and improve their practice and their students' learning. Such a process should include using certain methods of data collection, sharing of ideas, analysis, and action. In this sense, Suzan seems to be the only teacher who utilizes reflection effectively in her teaching among the four participants.

Another argument that I have based on the analysis of findings is that reflective practices are more compatible with the more sophisticated levels in the worldview model proposed by Graves (1981) and Beck & Cowan (1996). The motivation for self-reflection in the turquoise level can be the desire for understanding, in the yellow level it can be strategic long-range thinking, in the green level it can be the desire to meet the students' needs, and in the orange level it can be success driven. It seems like blue and lower levels may not see a value in reflective practices because of their value structures. In the blue level, compliance for rules and directions from authority are the most important drive for practices. The common external locus of control in this level may also make it difficult for teachers to see a value in self-reflection if they operate from this level. In the purple level, teaching may be seen from a survival perspective, in other words, trying to get by through the day rather than thinking about improvement through reflection. In the red level, power and dominance is desired and self-reflection for improvement may not be valued in this belief system.

Therefore I argue that teacher education programs, whether pre-service or in-service, should promote a developmental model for change in teachers' beliefs toward upper levels to help them become practitioners of their profession. The upper levels seem to be better fitted with a belief structure that may see a need or value in critical and reflective practices. The way to promote development toward up the levels in Grave's (1981) worldview model may be possible through learning about this model itself. The case studies that I wrote for each

participating teacher in this study, which include characterizations of their worldviews, could be used as a tool for reflection through another person's eyes. During our interviews, all four teachers agreed with the comments that I wrote about them in their case studies (Sara and Brian made minor changes). Suzan and Aylin thought I did a very good job of depicting their beliefs and practice; Sara admitted that conflicts are the dominant theme between her beliefs and practice; Brian wanted me to change some wording in his case study but other than that he agreed with what I wrote. Ideally, I hope that the case studies that I wrote for each teacher would be a reference point for them to engage in further reflective activities in order to better understand their own beliefs and practices. However as I explained in the previous section, not all of the teachers have the same potential to change and engage in reflective practices. As Beck & Cowan (1996) argue, people only change their beliefs and worldviews when the necessary conditions exist, such as when they are faced with conflicts or when they see a need for change. If people do not see a need for change, their worldviews remain relatively unchanged over time.

Changing teacher beliefs based on the reform suggestions is possible with teacher education, either in-service or pre-service. Ultimately, the purpose of such teacher education programs is to turn schools into places of learning both for teachers and students, not factories of skill and knowledge. Therefore, teacher education programs should be designed to promote change through understanding worldviews and helping teachers reflect on their beliefs and practices through this understanding. In such programs, openness to understand, learn and change should be the central theme for helping teachers understand their context, others' worldviews, and develop a more sophisticated thinking to deal with their problems.

Implications for Teacher Education

This study showed that every teacher has a different way of reacting to their environment and to the problems they face. For example, every teacher who participated in this study has different reactions and feelings about the standardization and accountability in education. This suggests that the idea of "one size fits all" is not the best approach for reform in education. While standardization and using standard tests to assess students' knowledge is an effort of increasing efficiency in an educational system, considering the pressure many teachers feel, perhaps the consequences of accountability on teachers (especially new teachers) need to be revised. Policies that put less pressure on teachers and emphasize learning more than test scores should be developed.

The analysis of the findings shows that studying teacher beliefs from a worldview perspective is a useful model that can contribute to the research about teacher beliefs. Participating teachers' beliefs about certain educational issues could have been investigated separately in different studies, but the worldview perspective provides a broader, more holistic picture of their belief systems. The worldview model takes into consideration not only what beliefs teachers have in relation to education, but also how these beliefs fit into a larger belief system, i.e. their worldview. Based on the findings of this research, it is possible to see that teachers held their beliefs about education related issues because these beliefs fit within their worldview.

Since it is argued in the literature that beliefs influence behavior more than knowledge, teacher beliefs and how these beliefs can be changed need to be understood (Kagan, 1992; Nespor, 1987; Pajares, 1992). As Pajares (1992) argue, teacher education programs have to pay attention to entering teachers' beliefs and adjust their curriculum accordingly. Pre-service teachers may have naïve and idealistic ideas about teaching and learning. When they start teaching and realize that it is not what they imagined, they feel stress and their long held beliefs from their student years become the dominant factor that

influence their behaviors rather than what they learned in a teacher education program (Pajares, 1992). In these situations, reflective and critical practices may help teachers to better understand their context and their beliefs and take action to improve their teaching. Assistance should be provided to teachers from educators to help them engage in such practices. Among the participating teachers especially Sara can use reflective practices to better understand and eliminate the conflicts she feels and take action to eliminate those conflicts. Brian may be less open to critical reflection in his teaching because of his worldview. His years of experience allowed him to establish his beliefs and perceptions about himself and his environment in a way that is difficult to change. He matured within the thinking system of the blue worldview and since this thinking system works for him, he feels no need to change it.

Suggestions for Future Research

Further investigation of teachers' beliefs from the worldview perspective and testing the usefulness of this approach in understanding teacher beliefs and its utility as a tool for reflective practices and change is needed. Once the nature of teachers' beliefs is better understood based on the worldview perspective, it is possible to develop critical and reflective methods that help teachers understand their beliefs in relation to their social and political context and use this understanding for improving their practice and their students' learning. These methods may also catalyze change in teachers' worldviews toward upper developmental levels, in other words, toward more open minded, questioning, and accepting attitude. Such methods should be an integral part of teacher education programs.

Limitations of the Study

The most important limitation of this study is the complexity of people's worldviews. Worldviews cannot be directly observed; however, since worldviews are belief systems, it is possible to make inferences about people's worldview from their beliefs. Beliefs are inherently held constructs and therefore the only way to understand peoples' beliefs is to talk with them and observe their behaviors. Studying beliefs has an interior focus, in other words the interior of people's mind is the focus of research. Since the only access to people's interior is communication, the researcher has to trust what people say about their beliefs. Therefore trustworthiness becomes the quality criteria in this type of research. In other words, individuals have to be trusted that that they are telling the truth about their beliefs. However, it is possible that they have not given considerable thought to what they believe about a certain issue, they may lack the language to talk about exactly what they believe, they may want to give a certain image about themselves to others, or they may not want others to know what they believe. It is even possible that individuals may be fooling themselves about what they believe. All these possibilities makes it difficult to access people's belief and hence their worldviews. Because of this complexity, the information obtained about people's worldview can only be partial and limited.

Despite this complexity, it is possible to achieve trust in the quality of data obtained in research about beliefs or worldviews by using the quality criteria suggested by Guba and Lincoln (1989). Their suggestions for quality include trustworthiness, which is grounded in four criteria: credibility, transferability, dependability, and confirmability. To ensure credibility in this study, I used multiple methods of data collection that included interviews, observations, surveys, and casual communications. Prolonged engagement was also another method I used to ensure credibility. I addressed the transferability criteria by using thick descriptions of participants' beliefs, practices, and their context. This way, readers of this study can make judgments about the applicability of this study in other situations. The

dependability criterion is addressed through clear description of methods I used in this study, which did not change since the planning period of this study. To address confirmability criteria, I tried to form a hermeneutic circle between the participants and me through communication of interpretations and I asked for feedback from each one of them. This allowed me to correct some misunderstandings and mistakes in my interpretations and writings. Despite these quality criteria that I utilized, I cannot claim that my understanding of the participating teachers' worldviews is absolute.

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Address: Faculty of Education, Department of Primary Education, Division of Science Education, Hacettepe University, Ankara 06532, Turkey.

E-mail: yyalaki@hacettepe.edu.tr