MATHEMATICAL AND THEOLOGICAL BELIEFS: A COGNITIVE SCIENCE PERSPECTIVE

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During the course of teaching mathematics for over twenty years at various levels (middle school, high school, and college), it became apparent to me that factors other than just mathematical knowledge often played a key role in the achievement of some of my students. In recent years, research studies of mathematical performance have considered more than just knowledge, facts, concepts, and procedures. It is now recognized that control decisions and processes, beliefs about the nature of mathematics, attitudes, and other affective variables have tremendous effects on students'(at all levels) mathematical performance. Students often have conceptions about the subject matter they study and themselves that affect the decisions they make in learning mathematics and ultimately in their mathematical achievement. Many classroom teachers have become aware of acute differences among their students in their conceptions of what it means to do and to learn mathematics and in their self-confidence in learning mathematics. It has become evident that the attitudes and beliefs about mathematics and themselves that students bring to the classroom, as well as their mathematical knowledge and skills, significantly affect their mathematical behavior and performance.

Likewise, I eventually came to the realization that a beliefs-performance link existed not just for my students but for me, their teacher, as well. The nature of *my* beliefs about the subject matter and about its teaching and learning plays an important role in shaping my instructional practices. Several researchers have proposed theoretical models to guide research on learning behaviors and the development of teachers' knowledge. In each model, the development of autonomous learning behavior for students and the development of teachers' knowledge, are heavily influenced by internal beliefs. These theoretical frameworks imply that the things the teacher says and does, the beliefs and expectations held by the teacher, and activities in which learners are expected to participate are all ways in which teachers influence students' internal beliefs and learning behaviors. Key questions being asked include: How do beliefs form? How do they evolve? How do people modify their beliefs? Why do people claim one set of beliefs but appear to behave in ways inconsistent with those espoused beliefs?

Perhaps, I should back up at this point to note that my first encounters with the term "belief" occurred not in the context of mathematics or education but in a theological sense in the context of the Bible. As a child being reared in a Christian home and strictly consistent in church attendance (without choice), I was taught that "believing" certain ideas about myself, others, life, God, the hereafter, etc. had eternal importance. As I encountered scriptures such as John 6:47, "...he who believes has everlasting life" and Matthew 21:22, "If you believe, you will receive whatever you ask for in prayer," it became clear that one's beliefs had profound implications both for this life and the next. After I became interested in the role that mathematical beliefs played in learning and teaching the subject of mathematics, I found myself wondering about similarities and differences between these two seemingly very different types of beliefs. This led me to ask questions about how an individual might come to acquire a specific set of beliefs and about the relationship between beliefs and behavior.

By examining the role and nature of beliefs in both mathematics and theology, some intriguing questions arise. In fact, it is the questions themselves that are perhaps most interesting since I cannot offer final, definitive answers to any of them. However, through the examination and discussion of these questions and issues, we may gain clearer insights into our own beliefs and their implications for our future learning and our Christian faith.

In general, these comparisons involving mathematical and theological beliefs include such questions as:

1. What are the similarities (how they are developed, modified, acted upon, etc.) between mathematical and theological beliefs?
2. What are the differences between mathematical and theological beliefs?
3. How do "authorities" in both mathematics education and Christian education think about and study beliefs in their respective fields?
4. Can the perspectives and theories from one field help to enlighten the understanding of the other?

Clearly, these are broad (and deep) questions that go beyond our scope here but I would at least like to propose them, offer a few observations on some of these questions, and leave you to continue thinking about possible answers. I will first give an overview of the research on mathematical beliefs. Secondly, I will mention some work done in Christian education relating to theological beliefs. And finally, I will offer some observations to compare the two.

Mathematical Beliefs: **Historical Perspective and Definitions**

Interest in research on mathematical beliefs is relatively recent. Around the turn of this century, there was some interest among social psychologists in the study of beliefs and their influence on people's actions. However, in subsequent decades, that interest faded and nearly disappeared as a topic in psychological literature. This was partly due to the difficulty in accessing beliefs for study and partly due to the rise of associationism and behaviorism.

The advent of cognitive science in the 1970s created a place for the study of belief systems in relation to other aspects of human cognition and human affect. The 1980s saw a resurgence of interest in beliefs among scholars from various disciplines including psychology, political science, anthropology, and education.

Among educators, interest in the study of students' and teachers' beliefs and conceptions was prompted by information processing theory and other developments in cognitive science. Research on teaching and learning began a shift in the 1970s from a process-product paradigm, in which the object was to study peoples' behaviors, to a focus on thinking and decision-making processes. The shift of focus to cognitive processes led to an interest in identifying and understanding the composition of "belief systems and conceptions" underlying students' and teachers' thoughts and decisions.

Although still under the influence of behaviorism, there were occasional studies in the 1960s and 1970s, conducted mainly by attitude researchers, that directly or indirectly addressed students' or teachers' beliefs and conceptions. Although few of these were related specifically to mathematics education, those that were dealt mainly with general attitudes and feelings about mathematics as a whole or different topics within mathematics, and the correlation between attitudes about mathematics and mathematics achievement. Since 1980, many studies in mathematics education have focused on students' and teachers' beliefs about mathematics teaching and learning.

Despite the current popularity of beliefs as topic of study, the concept of belief has not been dealt with substantially in the educational research literature. A major problem in the literature has been the difficulty of defining precisely the construct of belief, of determining exactly what it includes, and how it differs from other constructs such as knowledge and attitude. There has even been disagreement about whether beliefs and beliefs systems should be considered as belonging to the affective domain or as purely cognitive. Schoenfeld (1985), for example, places beliefs "at the intersection of the cognitive and affective domains." For the most part, researchers have just assumed that readers know what beliefs are, while in some cases, various studies of beliefs have examined very different variables in students and teachers.

While most interest in attitudes and affect have come from social psychology, interest in beliefs and belief systems has come mainly from cognitive psychology. Although beliefs, attitudes, and emotions are used to describe a wide range of affective responses to mathematics, these constructs vary in the stability and intensity of the responses they describe. Also, beliefs seem to be more cognitive in nature and are developed over a relatively long period of time.

Another explanation for the scarcity of earlier discussion on beliefs is the difficulty of distinguishing between *beliefs* and *knowledge* (Thompson, 1992). Because of the close connections between them, distinctions between beliefs and knowledge are fuzzy and researchers have noted that people often treat their beliefs as knowledge. One feature of beliefs is that they can be held with varying degrees of conviction. Another feature of beliefs is that they are not consensual. Semantically, *belief*, as distinct from knowledge, carries the connotation of disputability - the believer is aware that others may think differently. Knowledge, then, must meet certain criteria involving standards of evidence but beliefs, on the other hand, are often held or justified for reasons that do not meet those criteria.

The idea of a belief system is a metaphor for examining and describing how an individual's beliefs are organized (Green, 1971). It might be useful from a structural point of view, to conceive of a belief system in a similar way that we think of a cognitive structure. As such, belief systems are dynamic and undergo change as individuals evaluate their beliefs against experience. Schoenfeld

(1985) refers to mathematical belief systems as the individual's mathematical world-view, that is, "the perspective with which he approaches mathematics and mathematical tasks."

Some researchers define mathematical belief systems more specifically, claiming that belief systems comprise one's subjective knowledge about self as a doer of mathematics, the nature of mathematics, the environment of mathematics, and mathematical tasks. Thus, it is differentiated from "objective knowledge" which must be logically true or externally justifiable as well as being believed by the individual. It is clear that the concepts discussed here overlap and intersect in numerous ways. Each both influences and is influenced by others. Beliefs often interact with and, at times, shape attitudes and emotions and beliefs influence decisions made while doing mathematics.

Research on Mathematical Beliefs: An Overview

Studies of individual's mathematics beliefs and conceptions have focused previously on beliefs about the nature of mathematics or problem solving, and beliefs about mathematics teaching and learning. Some have examined the relationship between certain beliefs held by students and their mathematics performance or problem-solving behavior. The same dimensions of beliefs have been examined in teachers - both preservice and inservice. Some attempts have been made to examine the relationship between teachers' beliefs and their instructional practices.

Ball (1987) has proposed five dimensions of teacher beliefs: about mathematics, about learning mathematics, about pupils as learners and "doers" of mathematics, about teaching mathematics, and about learning to teach (or getting better at teaching) mathematics. This framework is often used to research and discuss the current mathematical beliefs of both students and teachers. We will now examine the conclusions of research that has looked at beliefs in some of these dimensions.

The dimension of **Beliefs About Mathematics** encompasses how someone would answer such questions as: What is mathematics? What kind of knowledge is it? What do mathematicians do? How important is mathematics? An individual's conception of the nature of mathematics can be viewed as that person's conscious or unconscious beliefs, concepts, mental images, and preferences concerning the discipline.

Various conceptions of mathematics, based on a philosophy of mathematics, have been identified as being documented in empirical studies. Ernest (1988) distinguished among: 1) the **problem solving view** which see mathematics as a dynamic, continually expanding field of human creation and invention with its results open to revision, 2) the **Platonist view** which views mathematics as a static but unified body of knowledge, a realm of interconnecting structures and truths that are discovered not created, and 3) the **instrumentalist view** which envisions mathematics as an accumulation of unrelated facts, rules, and skills to be used by the trained artisan in pursuit of some desired end. Lerman (1983) identified two alternative conceptions of the nature of mathematics called **absolutist** and **fallibilist**. From an absolutist perspective, all of mathematics is based on universal, absolute foundations and is the paradigm of knowledge, certain, absolute, value-free and abstract, with its connections to the real world perhaps of a "platonic nature." From a fallibilist perspective, mathematics develops through conjectures, proofs, and refutations, and uncertainty is accepted as inherent in the discipline.

The research literature reveals a substantial proportion of the student population having a fairly narrow and limited definition of mathematics. Studies of students at the elementary, junior-high, and high school levels all yield fairly consistent results. The most common view of students is that *mathematics is computation* - "the four basics." Even to academically advanced pupils, mathematics means memorization of arithmetic facts and algorithms and "doing mathematics means following rules." To them, the goal of mathematics is to obtain right answers since mathematics is dichotomized into "completely right" or "completely wrong" Interestingly, although students feel strongly that mathematics always gives a rule to follow, they also believe that knowing how to solve a problem is as important as getting the right answer and also that mathematics helps a person to think logically.

In a landmark study of high school students, Schoenfeld found that students saw math as a body of knowledge to be memorized in bite-sized bits and pieces. However, this appears to contradict other beliefs from the same study that math is a creative discipline in which one can make discoveries and learn to be logical. Most all students believe mathematics to be a useful and important subject. However, even though a vast majority believe math has practical, everyday uses, they tend to view it as important and useful in society, but less so for them personally.

Research on beliefs has been highlighted by the results of research on problem solving. This research indicates that students' beliefs about math can play a dominant, often overpowering role in their problem-solving behavior. For example, students expect to solve a typical problem in an average of just under two minutes and twelve minutes is the average length of time given as to a reasonable period to work on a problem before you know it's impossible. These beliefs are certainly based on their prior classroom experiences but will cause students to be unwilling to persist in trying to solve challenging nonroutine problems.

Not all students share these views of mathematics, as evidenced by some ethnographic studies conducted from a constructivist perspective. When classrooms and instruction are organized in certain nontraditional ways, students may come to believe that mathematics is essentially a creative problem-solving activity. However, this view appears to represent only a minority of the general student population.

Results of studies involving teachers' and prospective teachers' (elementary and secondary) beliefs about mathematics are very similar to those of students. Some predominant assumptions about mathematics by prospective teachers include: doing mathematics means following set procedures step-by-step to arrive at answers, knowing mathematics means "knowing how to do it," and mathematics is a largely arbitrary collection of facts and rules (Ball, 1990). Although there may be some differences between elementary and secondary candidates in their view of mathematics, virtually all preservice teachers seem to take their assumptions about mathematics for granted. They do not seem dissatisfied with them, nor do they even consider them.

Even practicing elementary teachers rarely view the learning of mathematics as an activity that involves understanding, discussion, and construction of ideas. Rather, they usually view mathematics as a fixed body of knowledge to be memorized. These teachers rarely see mathematics as an expression of ideas and relationships and rarely seem to realize that mathematical formulas reflect underlying logical principles. It has also been found that teachers' assumptions about the nature of mathematical knowledge do indeed shape the way they communicate content to novices. Research suggests that teachers view computation as often a senseless activity for which meaning need not be present! In short, numerous studies have shown that many mathematics teachers and preservice mathematics teachers (though not all) believe that mathematics is a discipline composed of rigid rules and correct answers.

What a teacher considers to be desirable goals of studying mathematics, his/her own role as a student or teacher, appropriate classroom activities and emphasis, and acceptable outcomes of instruction, are all part of one's conception of mathematics learning and teaching. There is a clear indication that teachers' conception of the nature of mathematics is related to their ideas about how it is learned and how it should be taught. Pedagogical beliefs run parallel to one's beliefs about mathematics. There is strong evidence of relationships between beliefs about how students learn mathematics and beliefs about how mathematics should be taught, and between beliefs about the nature of mathematics and mathematics pedagogy. In addition, the literature suggests that the strongest influence on the way teachers teach is the way in which they themselves were taught in mathematics classes. This has important implications for university mathematics content and methods courses for preservice teachers.

Changes in Mathematical Beliefs

Studies with students and preservice teachers suggest that conceptions are not easily changed and that there is little likelihood of real change over the period of a single course. However, a key element in each study in which some change or modification of beliefs occurred was a disequilibration process, in the Piagetian sense. Individuals were provided opportunities where their mathematical belief systems were thrown into a state of unbalance. Through these experiences, students or teachers had an opportunity (although it was not inevitable) to reflect on and examine their beliefs in light of current experience. This process might then result in a restructuring of belief systems or perhaps only an assimilation of current experience into an existing belief system. The personal cognitive and emotional dissonance, however, gave the potential for challenging individual's beliefs by bringing awareness of them to the surface.

The studies of mathematical beliefs lead us to conclude that belief systems are relatively stable and resistant to change. These deep-rooted "theoretical entities" have likely been formulated over a long period of time and are not altered quickly. However, the evidence also suggests that beliefs are not simply static mental structures but are susceptible to modification in light of experience. An analysis of these studies also reveals diverse views among students and teachers of mathematics about the subject and how it is learned and should be taught.

Theological Beliefs*

From the Christian perspective, we know that belief of the Gospel is a gift from God (Eph. 2:8-9). We are totally dependent on the Father, through the Holy Spirit, to draw people to himself and give them the gift of faith. Yet, the church is mandated to teach and Christian educators investigate how it is possible to help people develop sound beliefs and mature in their faith. So we might ask, from the human perspective, what is it that shapes us to believe the things we believe? Those involved in Christian education are interested in a similar (though not identical) set of questions as those asked by mathematics educators. From where do beliefs emerge? What causes us to believe the things we do? What sorts of things does God use to develop belief in us? What is the relationship between belief and behavior?

Of course, all of us think that our beliefs are quite rational. We consider the evidence and draw logical conclusions. But in reality, theological beliefs are shaped by a variety of factors. Perry Downs, in Teaching for Spiritual Growth (1994), describes four such factors that, in combination, help shape our beliefs.

First, beliefs tend to follow the patterns of early childhood. That is, we tend to believe in accordance with how we were raised as young children. Second, beliefs tend to follow our commitments to particular people. As we become committed to a person or group of people, we tend to adopt that person's beliefs. Third, beliefs tend to follow the lines of logical thinking. That is, we will believe only what makes sense to us. Finally, beliefs tend to follow behavior.

Emphasis on the first two factors mentioned above leads to an approach to educating for faith/beliefs based on social-learning theory. Lawrence Richards' approach based on individual relationships and John Westerhoff's approach rooted in the faith community are two such perspectives and are influenced by the social learning theory of Albert Bandura. The basic assumption of the socialization approach is that faith is learned more like culture and is best passed on through relationships and modeling. God uses the relationships and examples of the Christian family and community to communicate the content and substance of faith to children, and He will regenerate and then bring them to faith through the process of socialization.

The fourth factor proposed by Downs, that beliefs tend to follow behavior, is an important position in explaining the relationship between beliefs and behavior. Downs and some other Christian educators take the position that we have a greater tendency **to believe what we do than to do what we believe**. This perspective says that because of the power of experiences to shape beliefs, we will order our beliefs according to our behavior, and that much of our belief system will be a result of how we have lived. There are times when we realize that our stated beliefs and behaviors do not match. When such cognitive dissonance happens, we usually will change our beliefs. This may be because behavior is public but beliefs are private. It is easier to say, "I don't believe that any more" than it is to say, "I am being hypocritical." Therefore, we change our belief systems to match our behaviors.

Of course, for the Christian, there is another option. We can repent of sinful behavior, confess our sin, and bring our behavior back in line with our beliefs. Thus, repentance and confession are powerful means to relieve the cognitive dissonance that results from behaving in ways that contradict our beliefs.

If behavior shapes belief, how can we help shape the experiences of students to help them believe (Christian theology or to attain positive mathematical beliefs)? How can we influence lives in such a way as to provide experiences that will mold students' beliefs? One approach is to actually control life experiences to influence belief. Through rigid rules and regulations, some institutions strive to regulate lives in determine beliefs. However, rigid control fails to acknowledge human dignity and is an expression of behaviorism in its desire to manage behavior through environmental influences.

Even though we cannot totally control the life and learning experiences of others, we can help them to think about and **interpret** these experiences. We hold tightly to beliefs that are shaped by experience. The lessons of life are held much more firmly than the lessons of formal education. Teachers can ask, "How do you make sense of that (theologically)?" or "What is this experience doing to your understanding of God?"

Some of the most significant theories and models in Christian education which relate to the acquisition of beliefs come from a cognitive-developmental perspective. From Piaget's theory of cognitive development with its emphasis on stages, Lawrence Kohlberg framed his theory of the stages of moral development. This theory, based on the study of people not scripture, identifies six different stages in the conception of justice which appear in invariant sequence. Closely related to Kohlberg's theory is the theory of faith development proposed by James Fowler (1981). He has proposed six structural developmental stages of faith through which human faith may progress. Fowler argues that all people believe in something, and in this sense all people have faith. Since the content of our faith does matter, faith development theory considers *how* people believe, examining the deep structures of human faith and exploring the ways people hold the content of their faith.

From this cognitive developmental perspective, the task of the educator (parent, youth pastor, teacher) is to help create an environment in which people can grow. There is little or nothing we can do to change the pattern of development. We are responsible to create the environment that facilitates God's natural order and his supernatural intervention in the lives of his people.

Faith and Beliefs

While the mathematics educator must differentiate between beliefs, attitudes, and knowledge, the religious educator is more concerned with defining beliefs and faith. C.S. Lewis in *Mere Christianity*, describes faith as the art of holding on to things your reason has once accepted, in spite of your changing moods. In this sense, one must then train the habit of faith to maintain one's beliefs. Fowler (1981) offers a critical distinction between faith and creed (which I might call, in one sense, "beliefs"). He reminds us that faith is dynamic, evolving, and relational - an integral part of our life. It shapes the way we see and make meaning of our lives, controlling our values and perceptions. In this definition, faith is not static, but dynamic, influencing the way we see and relate to the world around us. This view does not reduce faith to a cognitive list of beliefs by which, if one asserts them to be true, one would be saved. This is much closer to the historical concept of belief than the more modern perspective is. In contemporary Christian usage, belief is reduced to a purely cognitive construct without its subsequent affective and volitional components. But historically belief meant *by-life*, meaning that what one believed was what one lived by. It was unthinkable to claim that one's belief did not shape one's life. This is, I think, an important insight on the true nature of faith and belief.

Wilfred Cantwell Smith (1977, 1979) takes issue with the modern identification of *faith* with *belief* and notes the historical evolution of the term belief. Belief he takes to be "the holding of certain ideas." In religious contexts, it arises out of the effort to translate experiences of and relation to transcendence into concepts or propositions. Belief may be one of the ways faith expresses itself but one does not have faith in a proposition or concept. Faith, rather, is the relation of trust in and loyalty to the transcendent about which concepts or propositions - beliefs - are fashioned. He characterizes faith in contrast to (in the modern sense) belief:

> Faith is deeper, richer, more personal. It is engendered by a religious tradition, in some cases and to some degree by its doctrines; but it is a quality of the person not of the system. It is an orientation of the personality, to oneself, to one's neighbor, to the universe; a total response; a way of seeing whatever one sees and of handling whatever one handles; a capacity to live at more than a mundane level; to see, to feel, to act in terms of, a transcendent dimension.

Smith also give a persuasive demonstration that the language dealing with faith in the classical writings of the major religious traditions never speaks of it in ways that can be translated by the modern meaning of belief or believing. Rather, faith involves an alignment of the heart or will, a commitment of loyalty and trust. Faith is a mode of knowing, of acknowledgment. One commits oneself to that which is known or acknowledged, and lives loyally, with life and character being shaped by the commitment. He notes that the early translations of "pistuo" and "credo" into "I believe" were not essentially mistaken. For until the early modern period (sixteenth century on) "believe" carried much the same range of meaning as that associated with "to set the heart upon." Literally and originally, 'to believe' means 'to hold dear': virtually, to love. I like the definition that faith is loving ("believing" in the original sense) God enough to obey Him! Gradually during the seventeenth and eighteenth centuries, secular usage of the words *belief* and *believe* began to change. Following by about a century, religious and ecclesiastical usage underwent the same changes. By the nineteenth century, the change to the modern usage was virtually complete.

Concluding Remarks

As people interact with their environment, some experience no conflict between their beliefs and their practice, some learn to live with unresolved conflicts, and others seem to reorganize their beliefs in response to the pressures encountered in their environment. From the theories and research of cognitive science, several ideas have been offered to account for what appear to be contradictions between a person's mathematical beliefs and his/her behaviors. Can any of these also help to explain why some peoples' lives do not seem to be consistent with their professed theological beliefs?

Discrepancies between professed beliefs and observed practice/behavior can sometimes be explained in part by the way beliefs have been measured. Reliance on verbal responses to questions posed at an abstract level of thought as the only source of data in problematic. Some beliefs professed by people are more a manifestation of a verbal commitment to abstract ideas than of an operative theory of practice. These kinds of inconsistencies among inservice teachers, for example, may be fewer than among novice teachers who have not had many occasions to operationalize and test those ideas and modify their views accordingly.

The political climate may also account for some of the observed discrepancies: state- or local-level policies and laws may influence teachers' practices without necessarily affecting their views.

Historical events such as the current reform movement in mathematics education and the publication of documents such as the NCTM's *Curriculum and Evaluation Standards* may influence people's verbal expressions.

Also, there is a great deal of knowledge necessary to successfully implement certain mathematical behaviors (teaching or learning). Some inconsistencies between professed beliefs and practices may be manifestations of espoused ideas that cannot be realized because the persons do not possess the skills and knowledge necessary to implement them.

Research indicates that the extent to which peoples' conceptions are consistent with their practice depends in large measure on the persons' tendency to reflect on their actions_to think about their actions vis-a-vis their beliefs. This process does not necessarily resolve all tensions and conflicts between beliefs and practice but it is by reflecting on their views and actions that people gain an awareness of their tacit assumptions, beliefs, and views, and how these relate to their practice.

Another possible explanation for discrepancies between professed beliefs and practice lies in Green's (1971) description of three dimensions of belief systems. The first dimension has to do with the observation that a belief is never held in total independence of all other beliefs, and that some beliefs are related to others in the way that reasons are related to conclusions. Thus, belief systems have a quasi-logical structure, with some primary beliefs and some derivative beliefs.

The second dimension of belief systems is related to the degree of conviction with which beliefs are held or to their strength. Beliefs can be viewed as either central or peripheral the_central ones being the most strongly held beliefs, and the peripheral ones those most susceptible to change or examination.

The third dimension has to do with the claim that beliefs are held in clusters, more or less in isolation from other clusters and protected from any relationship with other sets of beliefs. This clustering prevents crossfertilization among cluster of beliefs or confrontations between them, and makes it possible to hold conflicting sets of beliefs.

This structural model of beliefs would explain the possibility of teachers stating that they believe a certain mode of instruction is optimal for student learning and yet not be using such methods because the principal prefers an alternate approach. In this example, the belief that pleasing the principal is important (perhaps for keeping one's job), is a central, more strongly held belief, than the one that says teaching method X is what I want to use. I might also believe in a God that expects me to do certain things with my life and yet believe more strongly that I have plenty of time later to serve God and that I deserve to "enjoy life" in the present. I will most likely act on those beliefs I hold most strongly.

The relationship between mathematical conceptions or theological creeds and actual practices is not a simple one. Yet, an assumption that appears to underlie most theories and investigations until very recently is that the relationship is one of linear causality, where first come the beliefs and then follows the practice. The research literature, however, suggests that **the relationship is more complex, involving a give and take between beliefs and experience and thus, is dialectical or interactive in nature.** There is support for the claim that beliefs influence practice; beliefs appear to act as filters through which people interpret and ascribe meanings to their experiences as they interact with other people and the subject matter. But, at the same time, many a person's beliefs and views seem to originate in and be shaped by experiences. By interacting with the environment, with all its demands and problems, people appear to evaluate and reorganize their beliefs through reflective acts, some more than others.

In summary, there appear to be several parallels between mathematical and theological beliefs and in fact, these parallels would generalize to all cognitive beliefs.

- Beliefs are formed over an extended period of time.
- Beliefs are robust and deep rooted.
- We hold most tightly to beliefs that are shaped by our experience.
- We are most likely to modify our beliefs when we are aware of them and see them as "problematic."
- Beliefs and behavior are interrelated in complex ways.

Perhaps the most important difference between these two types of beliefs rests on the difference between the natural and the supernatural. Mathematical and other purely cognitive beliefs are acquired and modified in natural ways. But as Downs (1994) points out, faith development is the meeting of the natural with the supernatural. The supernatural element is the acceptance of the content of the Christian faith (1 Cor. 12:3). The natural element is in the way that content is believed. If it is true that God has designed humans to have faith and that the structure of our beliefs is similar to what cognitive scientists have theorized, then it may also follow that even our belief acquisition and faith development will follow these same natural patterns. Conversion is a change in the *content* (what we believe), not necessarily the structure (how we believe) of our faith. The Christian faith is unique in its content, but because it is exercised by human beings, it is not unreasonable to suppose that its acquisition and development will follow the natural processes of learning that God has designed.

NOTE

*I am using the term "theological" in a very broad sense (which may disturb some readers) to mean the study of God, religious truth and questions of ultimate reality (metaphysics).

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