A Christian Constructivist? The Impact of Worldview on Learning Theories and the Mathematics Education Research Community

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Tensions between Christians and the Academy

We begin with a story of Jeff's graduate school experiences at the State University of New York at Buffalo in the mid 1990s. He completed several graduate seminars in the area of philosophical bases for theory construction in mathematics education. The prevailing worldview in the readings and in the seminars was agnostic and was influenced by postmodern assumptions about meaning and authority as situated in the individual knower. These assumptions were echoed in much literature in mathematics education that espoused a radical constructivist epistemology (cf., Grouws, 1992).

In response to this environment, Jeff felt compelled to follow the call of Christian writers such as Os Guinness and Francis Schaeffer to engage the intellectual community from a Christian perspective. Jeff argued in these seminars that God's Trinitarian nature, the establishment of multiple languages, and the ability of humans to communicate through language needed to be considered key components to fully understand how people come to know and understand mathematical ideas. These efforts met with resistance from both fellow students and professors who argued that agnosticism is the only tractable academic position regarding God's existence and that it is not possible to integrate theological aspects into theories about human knowledge construction.

Concurrent with Jeff's graduate school experiences, Dave completed his dissertation at Northern Illinois University. Like Jeff, Dave was troubled by radical constructivism and a commonly associated notion of intellectual and moral relativism. In response, he carefully delineated his concerns with this learning theory in the introductory chapter of his dissertation. Although his dissertation committee was composed of four committed Christians, Dave was surprised that none of these members chose to address this issue in either personal discussions or the final defense. To the contrary, these Christian mathematics educators seemed content to maintain a sharp distinction between their personal faith and their professional research. To Dave's further surprise, the outside examiner for the dissertation defense, an Orthodox Jew, did raise this issue of worldview during the defense and noted that he also shared the concern of the tendencies toward relativism in the theory of radical constructivism.

Together, these experiences during graduate school set the stage for this present research agenda and paper. In response to our colleagues' tendency to avoid the application of religious principles altogether, at least outside of personal piety, we decided to carefully document instances of learning theories that emerged out of a variety of underlying worldview assumptions. Following this discussion, we then offer ideas on

how a Christian worldview can assist in the search for a learning theory to merge seemingly divergent perspectives.

Valid and true conclusions from diverse starting points

We next look at three major researchers in mathematics education. In each case, we present a brief description of the researcher's main theory and then comment about the underlying worldview. The first example is Jean Piaget. His research spans multiple decades and a wide range of areas including cognitive psychology and mathematics learning. In particular, he applied his theory of stages of development to the understanding of mathematical functions (Piaget et al., 1977). He described a total of four stages or levels through which students pass along their way to gain an understanding of mathematical functions. Initially, there is a complete lack of coordination of the input and output variables. At the second stage, haphazard links between input and output variables are made in local cases. At the third stage, called sequential reasoning, students can work in an iterative fashion to find the next output based upon the preceding integer-based case. In the final stage, called generalized reasoning, students are able to completely covary the input and output variables, generating a general equation for the functional relationship. Piaget created this useful learning theory in the context of his background as a genetic epistemologist. His later theories of assimilation and accommodation resonate with many aspects of a radical constructivist paradigm.

A second example is Lev Vygotsky. In his account of higher psychological processes of the human mind, he argued that we must recognize a zone of *proximal development* (cf. Vygotsky, 1978 and reviewed in Good, Mulryan, & McCaslin, 1992) indicating that range of potential thinking and reasoning an individual may accomplish with peer or expert assistance as a complement to the traditional recognition of the zone of *actual development* describing independent accomplishments and achievement. His work on epistemology is often viewed by the mathematics education research community as a way of attributing knowledge to social interactions and language within a community of learners or thinkers. From this perspective, Vygotsky ascribed knowledge development to the human society in which one participates; for him, individual knowledge always has its origin in the imitation of more accomplished members of society or from apprenticeship activities (1978, pp. 88-91). This represents a corrective to the radical constructivist claim that knowledge would originate in the mind of an individual as they interpret their experiences and surroundings. The Vygotskian view, developed within the Marxist/Soviet culture between 1915 and 1935, attributes knowledge to the collective interaction system of a community that forges new ideas through collaboration and discourse. While this is a helpful acknowledgement of the power of language in the formation of knowledge, it has its origins in a system of thought, Hegelian dialectics, that would deny the relevance of "revealed religion" involving God's existence and character to such a project of describing the growth of human reasoning and knowledge (McTaggart, 1922/2000, pp. 222-225).

A third example is Jere Confrey. Her work centers on the understanding of exponential functions (Confrey and Smith, 1995). She describes complicated cognitive structures which allow a student to apply an imbedded composite unit to represent the quantity typically written in numerical form as 3^4. Later in the same article, she and her coauthor document ways in which students "split" more complex units into component pieces. Confrey operates within a radical constructivist framework. According to Confrey (1990), radical constructivists do not accept the notion that mathematical ideas actually exist, but rather "have chosen, for the time being, not to call the construct into question, but to use it as if it were real, while assessing its worthiness over time" (p. 109). In essence, by acknowledging this relativistic feature of constructivism, she discounts the possibility of absolute truth, especially one's ability to know it with certainty.

The struggle for coherency and consistency in building a learning theory

The preceding section documents a variety of valid and true learning theories that originate from researchers with a variety of underlying worldviews. We next take a more in-depth look at a fourth researcher, Paul Cobb. In this case, we seek to document his apparent struggle to resolve the tension between radical constructivism (where meaning is located in the individual knower) and social constructivism (where meaning must be negotiated in a learning community). A more detailed discussion of several varieties of constructivism, along with implications for the teaching and learning of mathematics and a critique of these theories from a Christian perspective, can be found in a book edited by Howell and Bradley (2001).

Cobb has published extensively in mathematics education research journals. His writings attempt to argue for the complementary nature of socio-cultural and radical constructivist positions. In his study of second grade children working with a hundreds chart, Cobb (1995) noted how different children seemed to "push together" these two approaches to understanding a mathematical concept. One child seemed to describe a strategy of working by tens and later by ones. Yet this same child reverted to counting on from one addend when asked to compute a sum. Cobb struggles to articulate what it means for two individuals to have the "same" meaning for a concept, developed individually and yet communicated in community. Cobb falls back on the notion of "taken as shared" to indicate that two individuals can agree on a single understanding of a mathematical concept.

Lerman (1996) reacted to this research by pointing out the inherent intersubjectivity in Cobb's analysis of this learning episode, an apparent limitation of a strict radical constructivist paradigm. He cites the example of students providing examples of even numbers based upon the rule that it can be written as the product of the number 2 and another number. This rule is then overgeneralized to include examples such as 1 (2 × ½) and ½ (2 ×¼). Lerman concludes by recommending that Cobb abandon efforts to resolve the tension between radical and socio-cultural constructivist paradigms.

Two years later, Cobb engages in a public debate with Patrick Thompson, another major figure in the mathematics education research community (cf. Berenson et al.,

1998). After Thompson provides examples that appeared to illustrate intelligent design, he challenges Cobb to ground his claim of the compatibility of diverse learning theories on objective reality. Instead of accepting this approach, Cobb relies on a more pragmatic strategy, stating that the twin notions of a practice and participation in practices are ways of forging an integrated account of learning and thinking without appealing to a notion of objective reality. Further, he moves to the position that what is effective is what the individual and community will embrace, and that the tendency to join what is working will lead to effective practice since it will be productive both for individuals and for groups. This position has problems as a comprehensive foundation, but it can be held within a tension with some appeals to ideals, to a notion of the good, or to external truth from an absolute source. On the other hand, these are precisely what Cobb's system lacks because he wishes to "avoid the lure of cosmology."

In summary, Cobb seeks to avoid any explicit reference to an underlying worldview upon which to build his integrative theory. At the same time, he seems to be moving toward a sense of philosophical despair because he is unable to provide evidence for his desire to combine two apparently inconsistent learning theories. As Christians, we respond to Cobb's yearning for explanation by praising our Creator God, trusting in Him as the source of all wisdom. We therefore expect a resolution of this underlying tension as part of God's design for the world. The next section seeks to articulate elements of a Christian response to Cobb's dilemma.

University in Diversity: Using a Christian worldview to search for a "grand theory"

A Christian worldview allows us to examine various perspectives in the epistemologically comfortable position of those who know what is known and how children come to know by reference to the revealed information from the Creator of those children. As God made us in His image, we are able to learn and to come to know in ways that echo God's character. God is a speaker and initiator of words: He spoke and the worlds were formed; light came into being because he said, "let there be light." Thus, it is clear that we have psycho-cognitive ways of developing knowledge by initiative, and by creative impulses. We can organize or bring order in some way that is reflective of God's creative words.

Yet, we are also created to live in response to God's words. This is also psycho-cognitive reality, in that we can develop meaningful ideas by thinking as God has given us the means to act and think independently. He has given us responsibility, as depicted in the narrative of the first three chapters of Genesis. We were given breath, set into relationship, called to give names to order the creation in a language system, and called to accountability for relating to God in keeping with a boundary, resisting the opportunity to eat from one forbidden tree.

We are also made in the image of God as a triune God. God says that he interacts within the three-person Trinity: Father, Son, and Holy Spirit. This suggests a community in which interaction is critical. Jesus provides an expression of this complex interaction in his prayer recorded in the 17th chapter of the Gospel of John. This aspect of

God's character suggests by way of analogy that the socio-cultural and language-oriented accounts of human knowledge construction in community are valid. Finally, the fact that the Trinity represents a unified tension between different persons who are together one God suggests a Christian base for integrating the individual psychological and the community-oriented sociological aspects of human knowledge.

As we move forward in our documentation of these tensions and the potential benefit of an articulated Christian worldview in this context, we operate with two distinct motivations. First, we are motivated to reach individuals. We strive to listen with mercy to the tensions that each person describes, to identify the person's attempts to either avoid or rationalize this tension, and to offer a Christian response with a combination of boldness and humility. Second, we are motivated to reach the broader research community. This paper represents an initial attempt to review the existing tensions in the writings of current researchers. We also seek to remain connected to this scholarly community with further contributions to the published results in our field (cf., Barrett et al., in press). Finally, we will continue to work to articulate more clearly and more publicly those elements of a Christian worldview that shed light on this controversy and offer hope for a resolution, and perhaps even a creative embracing, of the tension between the psycho-cognitive learning theories focused on the individual knower and the sociological and socio-cultural learning theories focused on entire learning communities.

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