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Changes in Epistemologies: Understanding Teacher Education from Constructivism and Sociocultural Theories

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I. Constructivism and Sociocultural Theories

1) Description of the situations in understanding the two theories

I have observed an interesting phenomenon in the western mathematics education society with respect to constructivism and sociocultural theories. It seems mathematics educators there can hardly get to the point of understanding of the two epistemologies and just fail to see the usefulness of taking the two different epistemologies in explaining many of our interests in mathematics education. The purpose of writing this paper is twofold; First, I argue that taking both constructivism and sociocultural theories be a great potential for understanding mathematics education, in particular teacher education. In my view, sociocultural theories are a useful tool in understanding teacher education matters as well as constructivism is. This paper will spend more time in making a connection between sociocultural theory and teaching mathematics. It, however, does not suggest any less value of constructivism in understanding mathematics teaching, but stresses usefulness of sociocultural theory as a potential theoretical framework in understanding teaching and teacher education in mathematics education. Second, I intent to introduce sociocultural theories by Vygotskian scholars in a more detailed way to the Korean mathematics education society where not much of talks about Vygotsky and his sociocultural theory seem to be under discussion. It is notable that in Korea Vygotsky has been introduced as a constructivist, in particular, a social constructivist, which is a very different approach from the westerners.

2) Theoretical Framework

In order to provide reasons for my argument I present three different theoretical understanding about the teaching of mathematics with respect to the changes in epistemologies. My first argument comes from the premise suggested by Brown, Cooney, & Jones(1990, p. 650) that "It makes little sense to interpret either students' goals

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for teachers' goals in isolation one from the other." The second argument comes from my observation of the current theories of teaching and learning where attention to both psychological and sociocultural mechanisms have been found in current theories of cognitive development because of their complementary strength. According to Goldsmith & chifter (1997, p. 41), psychological mechanisms promote individuals' reorganization of their own knowledge and understanding. And sociocultural mechanisms provide the context and stimulus for individual change, and they support the creation of new social and intellectual forms themselves. Thirdly, I suggest that the description of the two epistemological perspectives is helpful in giving up debating over whether learning is primarily psychological or social, and rather asserting the usefulness of coordinating the two epistemologies so that result from taking the two will help understand teacher education in mathematics education in a better way.

3) Constructivists' views of the teaching of mathematics

While traditional view of mathematics teaching is grounded in the belief that students learn by receiving clear, comprehensible, and correct information about mathematical procedures and by having the opportunity to consolidate, automatize, and generalize the information they have received by practicing the demonstrated procedures, constructivist views suggest moving away from beliefs and practice based on the transmissibility of knowledge toward beliefs and practice granting students greater agency in their own learning (Goldsmith & Schifter, 1997). Further along the line, the constructivist views advocate the kind of teaching currently suggested by the reform movement by NCTM (National Council of Teachers of Mathematics, 1989; 1991; 1995). The classrooms are organized around students' active explorations of mathematical topics, which an emphasis on "knowing why" as well as "knowing how." Instruction is informed by students' current understandings and requires flexible lesson plans in order to respond to an unpredicted but important question, conjecture, or confusion raised in class. Conversation is discursive as well as informational as teachers and students, together, work to understand mathematical ideas (Goldsmith & Schifter, p. 25). In general, constructivism represents a change in perspective on what knowledge is important and how knowledge is developed. According to von Glasersfeld and Steffe (1991), knowledge is not passively received from the world, from other, or from authoritative sources. Rather, all knowledge is created as individuals and groups adapt to and make sense of their experiential worlds.

Piaget(1985) viewed knowledge growth as an equilibration process, a continual adaptation of cognitive structures to new experiences. The equilibration process is often thought of as being composed of two

processes, assimilation and accommodation. Assimilation is defined as "the incorporation of an external element, for example, an object or event, into a sensorimotor or conceptual scheme of the subject". Accommodation is the modification of schemes in response to an object that does not fit with prior schemes (Piaget, 1985, p. 5). Piaget explained that, "There is no assimilation without accommodation because the scheme of assimilation is general, and as soon as it's applied to a particular situation, it must be modified according to the particular circumstances of the situation(Bringuier, 1980)." Actually adaptation is a whole whose two poles can't be dissociated.

According to Simon(1997), the act of assimilating anew object requires some degree of accommodation; the scheme is modified by incorporation of the object. The reverse argument can also be made. Accommodation, the development of a new or modified scheme, cannot happen in a vacuum. It always results from reorganizing and/or connecting preexisting schemes. Thus, accommodation is assimilation into evolving schemes; the set of relevant, available schemes defines the range of possible accommodations that can be made (p. 68). In understanding the role of a teacher, exploration of the possibility of the teacher experiencing these aspects of the equilibration process in the journey of teaching particularly focused on beliefs, changes of the beliefs, and further changes in practice will provide significant information.

The social constructivist ideas are incorporated more in the views to the traditional constructivist perspectives. It is possible to assume that many teachers are intrigued by the call to reform and want to move to make changes in their practice because they want to make their teaching better. They hear that there are new materials, teaching strategies, and curricula available, and they want to learn to use these new tools to help their students become better in doing mathematics. The emphasis on the use of technology in teaching mathematics is notable among various reform-suggested call.

Another important side of the constructivist perspectives is the emphasis on a new role of teachers. Rather than thinking of themselves as authoritative sources of information, teachers are expected to begin to recast their roles to be guides and directors of students' learning, selecting activities and posing questions to help students examine and rework their current mathematical understanding. Different thinking about the locus of agency for learning is emphasized as a significant shift for teachers. In consequence, students are expected to play a new role with more responsibility in their learning in the constructivist perspectives.

However, Ball (1993a) who is in the social constructivism pointed out an insight in understanding pedagogical thinking by teachers. She said teachers must have a

"bifocal perspective - perceiving the mathematics through the mind of the learner while perceiving the mind of the learner through the mathematics (p. 159)." This reflects the two imperatives of responsiveness and responsibility (Ball, 1993b. p. 374). The responsiveness means a sensitivity to the students' thinking, knowledge, and interests, and the responsibility means the teachers' obligation to carry out the curricular expectations of the school district and to teach consistent with their own sense of the "ideas and traditions growing out of centuries of mathematical exploration and invention (p. 375)." According to Steffe & Wiegel (1992), the most basic responsibility of constructivist teachers is to learn the mathematical knowledge of their students and how to harmonize their teaching methods with the nature of that mathematical knowledge (p. 17).

4) Sociocultural theorists' view of the teaching of mathematics

The basic premise of sociocultural approach is to believe that learning tales place not at the individual level, but at the social level. Therefore, the individual dimension of consciousness is derivative and secondary (Vygotsky, 1978). Although the learning process itself is considered to be very individualistic, a sociocultural theory of learning looks at the social dimension of the learning the first place. Another basic goal of a sociocultural approach to learning is to create an account of human mental processes that recognizes the essential relationship between these processes and their cultural, historical, and institutional settings. So although a primary interest of sociocultural theories is human mind (development of human mind), they try to provide accounts of human mind through processes that the human mind adopts. Learning can not be explained without the examination of social interactions that the human makes. This is a clear distinction between a sociocultural theory and a non-sociocultural theory of learning. For example, Piaget's theory of learning is not a sociocultural theory because Piaget's primary interest in a child's learning is not at the social level.

In sociocultural theories, the focus of a child's learning is at the level of potential development not just at the level of "where a child is at". Therefore, a child's learning is expected to go beyond his or her actual performance level. Naturally, an instruction should be tied more closely to the level of potential development than to the level of actual development. Vygotsky introduces the "Zone of Proximal Development(ZPD)" in explaining the potential learning: This zone is defined as the distance between a child's "actual developmental level as determined by independent problem solving" and the higher level of "potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1978, p. 86)." In

consequence, sociocultural theories have a clear focus on action, "mediated action", and "psychological tool" and consequently interdisciplinary features of learning are emphasized. More importantly, sociocultural theories emphasize that actors in a learning process are not an individual child alone. The role of adults (teachers particularly) are significant in a child's learning. When it comes to thinking of teacher education, this is why sociocultural theories are needed. Since mathematics teaching in classrooms is a particular situation in which intentional interventions by a teacher are expected to obtain students' learning of mathematics. Therefore, the examination of the role of a teacher is necessary in studying teaching.

Sociocultural theories transmit a message related to teaching and learning that teachers' listening to students' mathematical reasoning, and having students listen to each other should not be an end in itself. Although it is a necessary part of organizing instruction to address the mathematical issues that students are encountering, it is not sufficient. Therefore, views from sociocultural theories argue that the construction of knowing is not a matter of individual, solitary construction of understanding, but a dialectical process firmly grounded in a system of social relations (Cole, 1985; Lave, 1988; Vygotsky, 1978; Wertsch, 1985). These theories emphasize that all knowledge is socially constructed, regardless of whether it is an individual's personal understanding, the very intellectual disciplines that we seek to learn, or the social organizations in which we study, work, and play (Goldsmith & Schifter 1997). In particular, a Vygotskian perspective has started receiving the most attention within American psychological community over the past two decades (see, for example, Cole & Scribner, 1978; Rogott, 1990; Wertsch, 1985). Within the Vygotskian perspective, qualitative restructuring of thought are related to the acquisition and use of powerful new tools and signs for mediating thought (Luria, 1976; Vygotsky, 1978; Wertsch, 1985). These tools and signs are cultural creations and help to shape the structure and organization of individual thought by emphasizing particular, socially valued relationships and processes of reasoning. The means for intellectual change lies in the individuals' appropriation and exercise of these socially constructed mediators, as the tools and signs help to organize and shape their experiences and interpretations of the world (Goldsmith & Schifter, 1997).

The teacher is considered as an instrument in the establishment of how mathematical validity is determined in the classroom. Therefore, the question like Where does mathematical authority reside? arouse from the sociocultural theories. Interestingly, the issue of authority has raised by Perry(1970) and Belenky et. al(1986) even through they are not necessarily related to the sociocultural theories. In particular, Cooney(1994) made the connection between beliefs and authority by

explaining that as beliefs are isolated and the individual fails to see the world as a connected place, he or she tends to rely more on external authorities for the verification of truth. This connection again relies on the context of the development of the belief and the strength with which it is held. Beliefs developed in a context of evidence allow for deeper reflection and the acknowledgment of other ideas. Beliefs developed nonevidentially are more reliant upon the authorities which comprised the context of the structure of that belief (Eggleton, 1995, p. 23)

II. Reconceptualization of the Role of Teachers

1) Relation to the NCTM-originated reform

Part of the reform process does involve learning to use new educational materials, so-called technology as a representative. However, it is one thing for teachers to accept the current wisdom about what the technology can do in good mathematics classes. It is another thing to make their classroom in the way they accept. Further, it will be one thing for teachers to use the reform-suggested technology. It will be another thing how they are using it in the classroom. Unless this "how" side of practice is revealed, the whole picture of understanding about teacher beliefs and changes in practice that teacher educators want is not drawn. According to Schifter & Simon(1992), learning to implement new instructional materials and strategies is but one aspect of a much deeper change in teaching. In fact, without concomitant changes in fundamental beliefs about the nature of classroom activities, it is possible for teachers to assimilate new materials or strategies into traditional instruction or poorly defined instructional goals. These may be based in different-and even inconsistent-theoretical positions about learning, and may have been modified or used by the teacher in ways that preserve little of the intent of those who originally designed the materials or techniques (Goldsmith & Schifter, 1998, p. 26).

2) Teacher as authority in the classroom

New roles for a teacher are expected as part of the reconceptualization process. And the new roles are deeply related to teacher authority. When a teacher sees her as an authority in the classroom, a conception of learning is predicted on students' receiving information and on the teacher as the sole intellectual resource. Therefore, the sociology of the classroom become reflecting a hierarchical and unidirectional set of intellectual relationships. The important opportunities for learning are believed to reside in the teacher's having important things to say or show, and the students being ready and able

to take this all in and use it when called on to do so (Goldsmith & Schifter, 1997).

Autonomy seems to be in the same line with authority. Autonomy given to teachers is a key, but by no means simple, issue in shaping teaching. There is a clash between demanding a degree of autonomy for the teacher, and the need to ensure that those who do not have the requisite knowledge and preparation to exercise autonomy are not imply encouraged to make out as best they can. The degree of autonomy to be given to teachers must be a function of their preparedness, experience and training. Teachers should not be advised to follow by texts or other published schemes, and more importantly educators should not stop asking serious questions about any scheme, or how it might be improved.

When a teacher consider her as an autonomous agent in the classroom practice, she comes to believe that students' understanding is not reflected solely in her ability to execute rote procedures. The teacher begins to consider students as active agents in the constitution of their own knowledge without losing the role of the teacher as an active agent too. It seems that a shift in the social dynamic of the classroom toward greater intellectual interaction between teacher and student is expected in the notion of the teacher with autonomy.

As a final remark on teacher with authority, Cooney & Shealy's(1997) argument is helpful: To ask teachers to change may place them in an uncertain if not untenable position. At the very least, it requires that teachers be self-directed, autonomous, and resolute that their teaching of mathematics is both consistent with changes in mathematics and in mathematics education, and is in the best interests of students and society. I content that teachers need to be not only reflective in their practice, but also capable of internalizing many voices into a coherent philosophy of teaching mathematics.

3) Teacher's belief structure

Cooney and Shealy (1997) pointed out the importance of understanding the structure of teachers' beliefs and their relationship to change. Their focus on teacher change is from the perspective of developing teachers' belief structures in such a way that autonomy in evaluating alternatives in teaching mathematics is commonplace. They want teacher to develop the ability to see themselves as authorities, in that they can evaluate materials and practices in terms of their own beliefs and practice, and be flexible in modifying their beliefs when faced with disconfirming evidence (p. 88). The significance of this orientation in conceptualizing teacher change is that it acknowledges, without the orientation, teachers are buffeted and bandied about by proclamations stemming from local or national organizations.

III. Increased Attention to the New Roles of a Teacher In the Classroom

Reflected in this shift is a changing view of agency in student learning process, that is in line with what sociocultural theorists such as Vygotsky (1978) and Tharp and Gallimore (1988) suggested. Rather than decreasing the role of teachers in the student learning process, the sociocultural theories emphasize more active role of teachers in it. In fact, this increased attention to the role of teachers in the students' learning of mathematics is one of the key elements that sociocultural theories are identified differently from any other learning theories such as constructivism. By placing teachers at the center of a student's learning process, sociocultural theories characterize teachers as main actors in the learning process (Jeon, 2000). Therefore, an individual child alone is not any more a sole actor in creating knowledge. In other words, the child constructs his or her own knowledge as constructivists say, but the role of a teacher in the construction cannot be omitted in sociocultural theorists' view points.

In the boundary of sociocultural theories, teachers are expected to become more concerned with their own behaviors. The teachers should remain more focused on lesson design and their own teaching practice as well as the close details of their students' thinking. Since teachers are more knowledgeable, experienced, and acknowledged educational member of the group, a class, it is their role and responsibility to access students' understanding, monitor their process, and stimulate continued growth in mathematical understanding. Teachers are expected to reposition themselves as orchestrators, rather than conductors of mathematical inquiry in the classroom. In general, sociocultural mechanisms aim at providing the context and stimulus for individual change and they support the creation of new social and intellectual forms themselves.

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인식론의 변화: 구성주의와 사회문화주의를 통해 이해하는 수학 교사 교육

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본 논문의 목적은 두 가지이다: 첫째, 구성주의와 사회문화주의의 통합적인 이해를 통해 수학 교사 교육에서 사용할 수 있는 이론적인 잠재성을 토의한다. 둘째, 비고츠키의 사회문화주의에 대한 토의가 그리 많지 않은 상황에서 사회문화주의자들의 주장을 교사교육적 관점에서 설명한다. 학습을 개인적 차원에서 설명하는 구성주의와 학습을 사회적 차원에서 설명하는 사회문화주의는 그 발생 원리상 큰 차이점을 갖는다. 본 논문에서는 이러한 차이점에 대한 논란보다는 어떻게 이 두 가지 이론이 학생들의 수학 학습에서 교사의 역할에 대한 재조명과 이론적 지지 기반을 제공할 수 있는 가능성을 갖는지 다루고 있다.