Cognitive Mechanism of Constructive Activity Development

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In this paper, with respect to works of L. Vygotsky, A. Leont'iev, P. Anokhin and others, I will analyze the key concepts of the modern activity theory: structure of activity; zones of cognitive development; and instructional sequence of cognitive development. I will also consider comparative issues on the relationship between activity theory and constructivist approach. Based on this analysis, the conception of constructive activity[*] will be considered as an integrated theory. The main philosophical idea of this integration is that if constructivism intends to understand the world, and activity theory appeals for changing the natural and social reality, then conception of constructive activity aims on changing the reality through understanding.

First, what is activity? "Activity is a specific form of the societal existence of humans consisting of purposeful changing of natural and social reality" (V. Davydov, 1999, p. 39). Activity theory rooted in philosophy, psychology, sociology, and anthropology. The major beliefs of activity theory are: human activity changes nature; human beings change their own nature by activity (how people work implies how people think); social, cultural, and historical processes are important for understanding of individual's development.

Activity theory has its own view on the knowledge construction. There is no such a debate "whether knowledge can be transmitted by a teacher or it can be constructed by the learner" in the activity theory. The main principle of activity theory is *knowledge can only be constructed through the activity.* Studying the concept of activity in Soviet psychology J. Wertsch mentioned: "According to them [Leont'iev and his fellow researches], neither the external world nor the human organism are solely responsible for developing knowledge about the world. They argue that the key to the process is the activity in which the human agent engages" (J. Wertsch, 1979, p. 38). Some constructivists already paid attention to this principle. Activity, in whole, and mental actions, in particular, might be a starting point in the integration of constructivism and activity theory. L. Steffe and H. Wiegel (1996, p. 486) write: "Mental operations form strong connecting links between Soviet activity theory and constructivist approaches."

Comparing the two philosophical ideas, I would underline that if constructivism intends to understand the world, activity theory appeals not only for understanding but changing the natural and social reality. Though the activity

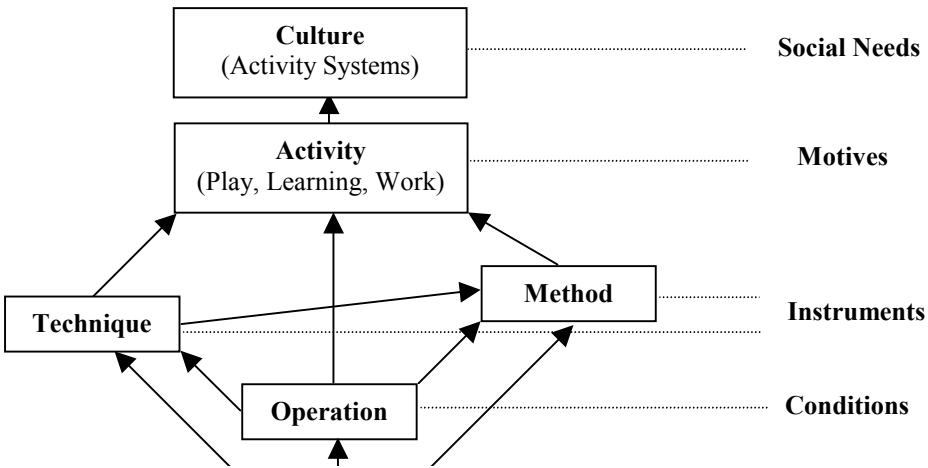
[*] The term "constructive activity" was first introduced by E. von Glasersfeld (1987).

theory "was born" as a philosophical and anthropological doctrine, nevertheless, it had and continues to have tremendous influence and importance for educational practice. Below I will consider "three elephants" or three main educational issues of modern activity theory: structure of activity, zones of cognitive development, and instructional sequence of cognitive development.

Structure of Activity

The issue of structure and components of activity is still remaining one of the unsolved problems of activity theory (V. Davydov, 1999). According to the fundamental work of A. Leont'iev on activity theory "Activity. Consciousness. Personality" (1977), the structure of activity includes such components as motives, goals, conditions, actions, and operations. There are three pairs of components in this sequence: activity – motive, action – goal, and operation – conditions. In other words, activity is motivated, actions are goal-directed, and operations are depending on conditions. Leont'iev explains that "the difference between actions and operations emerges … in the case of actions involving tools. For example, one can physically dismember a material object with the help of a variety of tools, each of which defines a way (an operation) for carrying out the given action (the dismemberment)" (Leont'iev, 1977, p. 107). Analyzing Leont'iev's structure of activity V. Davydov mentioned: "If we examine this structure, we notice the absence of the means of solving a problem. It seems clear that this component should be added" (Davydov, 1999, p. 45).

Actions usually come from an emerging problem or task (e.g., real-life situations, inquires, surprise situations, puzzles, paradoxes, sophisms) which reflects a cognitive conflict or intellectual difficulty and encourage student's curiosity. The way for carrying out goal-directed actions in the problem solving process is called an *operation*. The set of goal-directed actions and conditionally determined operations we call *a technique*. The set of techniques to accomplish the activity we call *a method*. Technique corresponds to actions and operations, and method corresponds to activity. Techniques and methods are means or instruments of solving a problem. Activity systems represent different aspects and domains of social and cultural life. Culture as a set of activity systems is relevant to social needs, activity is relevant to motives, techniques and methods – to instruments of solving a problem, operations – to conditions of problem, and actions – to goals of given problem (figure 1).



Zones of Cognitive Development

This concept is another "elephant" of activity theory. Vygotsky noted that the possibilities of genuine education depend not so much on the already existing student's knowledge and experience (level of actual development) as on the characteristics that are in the zone of proximal development. He wrote: "Pedagogy should be oriented not toward yesterday, but toward tomorrow in child development. Only then will it be able to create, in the process of education, those processes of development that are at present in the zone of proximal development" (Vygotsky, 1996, p. 251). Zone of proximal development is the distance between what child knows and his potential for knowing with the help of "more knowledgeable other". It is necessary to stress that in Western pedagogy the main attention is paid to the ZPD (zone of proximal/potential/nearest development) though Vygotsky considered ZPD as one of the domains between the lowest and highest levels of cognitive development. "We always should determine lowest threshold at which instruction may begin. But it is not the end of the deal: we should be able to determine the upper threshold of instruction as well. Only between these thresholds instruction might be fruitful" (Vygotsky, 1996, p. 251). The lowest threshold is the level of actual development (LAD) which contains the student's actual knowledge, skills and experience. Then follows the zone of proximal development (ZPD) which aims on cognitive change basically connected with the guided development of student's understanding. "The ZPD is the locus of social negotiations about meanings, and it is, in the context of school, a place where teachers and pupils may appropriate one another's understandings" (D. Newman, P. Griffin, M. Cole, 1989, Foreword by S. White). There is one more zone after ZPD. When Vygotsky wrote about the upper threshold, he didn't mean that it is equal to ZPD. Till now nobody has paid attention to this

important fact in Vygotsky's work. It is a new zone - zone that goes beyond the development of understanding. It is a zone of formation of student's creativity. Whereas in ZPD the functions of comparison, reproduction, assimilation, and coping are of primary importance, in a new zone the functions of construction, generation, and creation are most important. This upper threshold of instruction and cognitive development we call a zone of advanced development (ZAD). If ZPD is the interpsychological dimension where social activity and interpersonal dialog is taking place, ZAD is the intrapsychological dimension where advanced individual activity and intrapersonal dialog is going on.

Activity cannot be understood as simple internalization of ready-made standards and rules. S. Rubinshtein (1973) stressed that human activity presupposes not only the process of internalization but also the process of externalization when humans create new standards and rules. So, if the psychological outcome of ZPD is internalization, for ZAD – it is externalization. According to L. Vygotsky the guidance is crucial in helping student move from LAD to ZPD. We cannot say the same about student's transfer from ZPD to ZAD. In other words, if ZPD is a domain of guided cognitive change (understanding), ZAD is a zone of student's individual (independent) activity. Therefore, we consider ZAD as a domain of higher cognitive achievement and creativity which student may reach in the process of intense individual studies (figure 2).

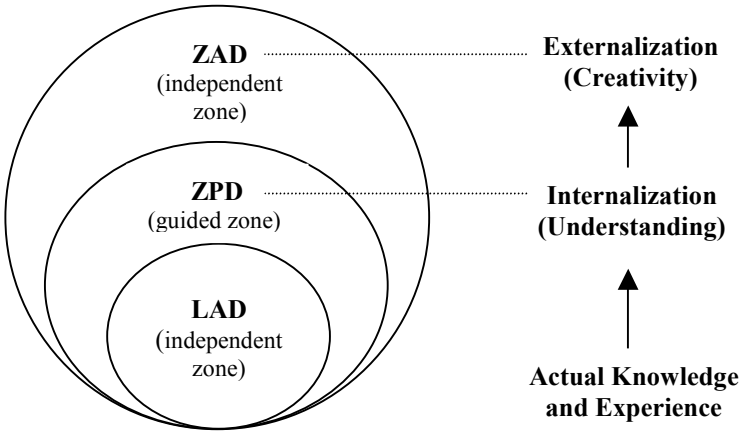


Fig. 2. Zones of Cognitive Development

Sequence of Cognitive Development

Human activity is conscious and it exists in both collective and individual forms. L. Vygotsky argues that determination of individual consciousness and cognition might be presented by the following sequence: *collective (social) activity – culture signs/symbols – individual activity – individual consciousness*. That is why, for Vygotsky and his fellows, it is very important to examine the transformation of all aspects of this schema in the study of the sequence of cognitive development. Based on this schema, P. Gal'perin and N. Talyzina (1968) worked out the conception of orientation and stepwise formation of intellectual actions that includes the sequence of following stages: orientation,

“hands-on” actions, thinking aloud, inner speech, and mental actions. *The conception of orientation* is a central idea in Gal'perin and Talyzina's (G&T) theory. There are actions with complete and incomplete orientation bases. For operating in the zone of proximal development complete and detailed orientation is efficient. At the same time, theoretical and experimental studies (O. Tikhomirov, 1999, p. 349) show, that in accomplishing creative activity and operating in the zone of advanced development incomplete but systems orientation is required. "Hands-on" actions is the "doing" stage in G&T model which include manipulations, modeling, physical actions, and experiments with external representations. During this stage "public" (peer and small groups learning, whole group discussion, etc.) discourse is crucial. This corresponds with "collective (social) activity" in Vygotsky's schema. Then "private" discourse (e.g., thinking aloud, inner speech) accompanies the development of student's mental activity. Needless to say, that two of these activity schemata complement each other by pointing out different aspects. In our research, we integrated Vygotskian and G&T models in order to design *a cognitive structure of constructive activity development.* This structure includes the following stages:

1. ***Orientation stage:*** cognitive entrance to the problem/activity/thematic unit guided by instructor (who defines the level of completeness of the orientation base), creating an intellectual difficulty (cognitive discomfort) by using challenging problems, real-life projects, paradoxes, misconceptions, surprise situations, fallacies, etc. From psychological point of view this stage reflects such elements of afferent synthesis as actualization and motivation.
2. ***Hands-on stage:*** approaching the problem using standard external representations given by instructor or chosen by students (manipulatives, physical objects, visual tools, etc.) as well as expression of initial students’ representations through a "public" discourse (e.g., exchange of students’ ideas, peer learning, small groups, whole class discussion).
3. ***Minds-on stage:*** a "private" discourse (e.g., students’ thinking aloud, inner speech) and development of students’ conceptual understanding. In this stage the primary attention should be on making inter- and intra-subject connections and development of students' internal representations (e.g., mental images, schemata, metaphors).
4. ***Generalization stage:*** reflection, extension, and construction. Focus should be on development of students' creativity using general methods for advanced problem solving and reasoning. It is also a stage of efferent synthesis and evaluation. If orientation stage reflects the level of actual development (LAD), hands-on and minds-on stages reflect the ZPD, then generalization stage is the zone of students advanced development (ZAD).

The advantage of this model is that it contains an attempt to create a sequence of instructional stages for cognitive development. One of the main disadvantages of

constructivism is an absence of such kind of instruments. Unfortunately, the point of confusion for teachers who are trying to implement a constructivist approach is that there is no clear procedure how to do it. Hopefully, an integrated conception of constructive activity "takes care" of this confusion.

Another concern is a difference in views on the role of representations in cognitive development. Constructivists P. Cobb, T. Wood, and E. Yackel (1992) reject the "representational view of mind". They ignore basic principles of theories of L. Vygotsky and J. Piaget according to which representations (culture signs and symbols) are necessary tools in the process of transition from collective (social) accomplishment of an activity to individual accomplishment. Sign systems "are the real bearer of human culture, the means by which individual activity and individual consciousness are socially determined. The incorporation of signs into the structure of a mental function (mediation through signs) links that function to culture. On the one hand, a sign is always supra-individual and objective since it belongs to the cultural world, but on the other, it is individual since it belongs to the mind of particular person" (V. Davydov, V. Zinchenko, 1993, p. 102). Therefore, an involvement of multiple representations into the process of constructive activity plays a significant role in mediation between an external reality and student's internal cognitive growth.

We also consider the cognitive structure of constructive activity development as *a functional system*. The main feature of functional system is its invariance. P. Anokhin and A. Luria stressed an importance of functional systems in brain research: it could sustain functioning regardless of partial damage of the brain. Approaching a situation of cognitive change, D. Newman, P. Griffin, and M. Cole (1989) "view the activity in the ZPD as constituting a functional system". At the same time they erroneously consider that “the zone of proximal development is a functional system for cognitive development” (ibid.). They wouldn’t have come to this conclusion if they had taken into account an existence of ZAD along with ZPD and the structure of functional system which includes afferent synthesis, decision making, anticipation, goal-oriented action, efferent synthesis, and evaluation (Anokhin, 1978). Because then it would become evident that functional system is a cognitive mechanism for the ZPD and ZAD construction, opposite to what D. Newman, P. Griffin, and M. Cole thought it to be.

Outcomes of the experiment on implementation of the conception of constructive activity in teaching and learning of secondary mathematics show important cognitive changes on students’ motivation, attitude, and confidence. The experiment took place from 1990 till 1996 in number of Russian high schools (Moscow, Kazan) with total enrollment of 650 students. After the experiment students' self-evaluation showed that 88% of them considered their

progress on high level, 8% - on average level, and only 4% of students responded that there was no progress in their learning of mathematics. 85% of students reduced their anxiety and obtained confidence in mathematical problem solving and reasoning. 76% of students changed their attitude from negative to positive toward mathematics. Before the experiment only 16% of students were interested in mathematics, but after it 84% of students were ready to continue study mathematics on the advanced level (M. Tchoshanov, 1996, p. 148).

Conclusion

Current stage of development of psychology of mathematics education is characterized by growing new learning theories and pedagogical approaches (e.g., constructivism, situated learning, etc.). There is an emerging necessity of integration of "new" theories with more traditional ones. It will create a polyphonic pedagogical environment and help to avoid artificial contradictions between relatively close pedagogical theories. The key advantage of polyphonic pedagogical systems before monophonic ones is that they can accumulate new integrative quality, which will allow improving education in a global community. Based on this idea, we considered an integration of activity theory and constructivist approach with respect to development of conception of constructive activity. The key pedagogical idea of new conception is that *knowledge can only be constructed through the oriented activity*, which follows the sequence of instructional stages: orientation, hands-on and minds-on actions, and generalization. The basis of orientation (complete or incomplete) determines the level of cognitive development: beginning with understanding in the zone of proximal development up to creativity in the zone of advanced development. The pedagogical strength of this conception is that some details of learning process may change but the pedagogical functional system, as a cognitive mechanism of constructive activity development, remains intact.

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