Activity theory in mathematics education

Iskra Nunez

Institute of Education, University of London

Cultural-Historical Activity Theory (CHAT) has been described as a “psychological and multidisciplinary theory with a naturalistic emphasis that offers a framework for describing activity and provides a set of perspectives on practice that interlink individual and social levels” (Barab, Evans and Beak, 2004, 199-200). In this report, I argue that CHAT provides a set of assumptions by which to understand and explain learning processes that occur for example in the mathematics classroom. This argument hinders on a review of the historical development of this framework. I close this report by bringing together some of the assumptions that underlie my future research in mathematics education.

Keywords: Cultural-Historical Activity Theory (CHAT), mathematics education, activity system.

The historical development of activity theory

The utilisation of CHAT (hereafter, AT) to study developmental processes and forms of human practices varies across disciplines such as work management, education, (Engeström, 2001) and human computer interaction (Kuutti, 1996). Thus, to understand what AT has to offer to the field of mathematics education is crucial to historically trace the assumptions that underpin the concepts in AT and to understand how the mathematics educational community has operationalised AT concepts.

In Cultural-Historical Activity Theory, the word activity does not refer to the practical immediate actions of human beings, such as reading or problem solving. Instead, the meaning of activity in the conceptual sense is rooted in classic German philosophy and is derived from the word tätigkeit. Schurig (1998) explicates that the conceptual richness behind tätigkeit has an emancipatory character. The historicity of AT is depicted in Hegel’s classics. Hegel is considered the first philosopher to point out that the development of humans’ knowledge is not spiritually given, but developed in history from living and working in natural environments (Engeström and Miettinen, 1999).

Later, the meaning of activity (tätigkeit) is conceptualised differently under historical materialism (Marx, 1945). Here, labour becomes the basic feature of human activity. Activity is not only performed to transform nature, but in the process of transforming nature humans themselves are cognitively transformed (Engels, 1940). This dual transformation never occurs in isolation; instead, it is accomplished in community with the help of others and/or with the help of instrumental means. (In AT terms, these instrumental means are called mediators of activity and are represented with the concepts of instruments/tools, rules, and division of labour).

Human activity is also seen as ‘object-oriented’ (Kaptelinin, 2005). That is, human activity is not random, but purposefully orientated towards the achievement of an objective (or object of activity). From historical materialism, the concept of activity cannot be trivialised with the common definitions of practical activities. It signifies a ‘revolutionary’, ‘creative’ and ‘self-changing’ practice in which the human subject produces the conditions necessary for her/his life, and at the same time, she/he produces her/himself.

In Soviet psychology, L. Vygotsky took the ideas of Marx and Engels to introduce a new model to explain human behaviors (Figure 1).

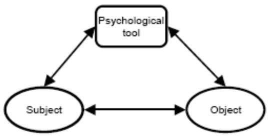

Figure 1: Mediated Act
[Adopted from Vygotsky (1981)]

This model is a triad of interdependent components: subject, psychological tool, and object depicting 'the mediated act' (Vygotsky, 1981). In contemporary activity theory, 'the mediated act' model is known as first generation activity theory (Engeström, 2001).

A. N. Leont'ev (1977, 1978), a student and colleague of Vygotsky, continued to develop the theory of activity. What has furthered the development of AT from the Vygotskian model to Leont'ev's conceptualisation is the inclusion of division of labour. Division of labour helps to differentiate between what is accomplished collectively or individually (Engeström and Miettinen 1999).

Although Leont'ev did not develop a graphical model like 'the mediated act', AT's theorists represent his work as a hierarchical activity structure (Figure 2). Thus, Leont'ev theoretical work is referred to as second-generation activity theory (Engeström 2001).

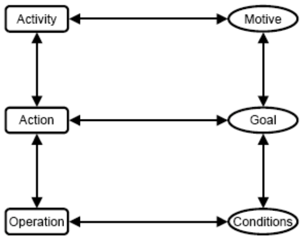

Figure 2: Hierarchical Activity Structure
[Adopted from Koschmann, Kuutti and Hickman (1998)]

Third generation AT refers to the work of Engeström (1987), who expanded the *activity system* (Figure 3) from the Vygotskian mediated act, by drawing upon concepts of mediation, collectivism, historicity, and object-oriented.

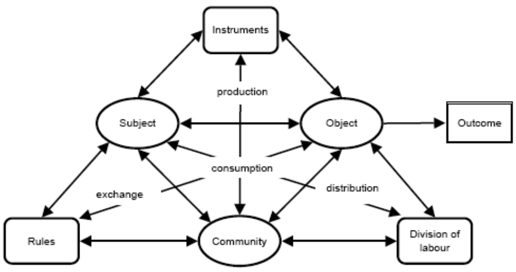

Figure 3: Activity System
[Adopted from Engeström (1987)]

To understand how the mathematics educational community has utilised the activity system's components, I give some examples of the operationalisation of these components to the mathematics classroom: The <u>*subject*</u> may be a single student, a class (Jurdak 2006, Williams, Wake and Boreham 2001, Zurita and Nussbaum 2007) or the educator (Hardman 2005, Hardman 2007, Jaworski, 2003). The <u>*object*</u> of activity may be described as long-term goals such as improving teaching, learning mathematical practices (see Kanes 2001; Venkat and Adler 2008) or short term-goals, such as passing an exam (see Flavell 2001, Roth 2003). This depends on who the subject is. The *community* may consist of the teacher and students (Jurdak 2006); it may also include family and policy makers (Venkat, H. and Adler 2008). The *instruments* may represent mathematics concepts, strategies, procedures, language, gestures, group work, and computing technologies such as computers, calculators, or interactive white boards (Coupland 2006, Groves and Dale 2005, FitzSimons 2005, Lim and Hang 2003, Zevenbergen and Lerman 2007). The *rules* may be represented as employing the correct language (Hardman 2005), assessments (Jaworski 2003), curriculum protocols, algorithms (Kanes 2001), questioning (Williams, Wake, and Boreham 2001) or whole class grouping by ability (Venkat and Adler 2008). Lastly, *division of labour* may be represented as assigning tasks, interventions, collaborative agreements, validation of solutions, or student-centred vs. teacher-centred pedagogies (Hardman 2005).

Further research

I have argued that an understanding of activity theory requires an understanding of the assumptions that developed from its genesis in German philosophy, followed by the contributions of the Soviet school of psychology, to its contemporary form in the work of Engeström (1987). My interpretation of the historical development of activity theory has led me to outline the following set of assumptions:

- Activity is viewed as a transformative process by which humans learn to physically change their environment and hence cognitively change themselves. (Engels 1940).
- Human activity is social and collective. The transformative nature of activity never occurs in isolation, but is accomplished with the help of others, say in a community, and with the help of the means of their labour, say instrumental means or instruments/tools (Marx 1845).
- Historicity: Activity is the historical product of human labour and collective societies. This implies that human activity may be seen as the result of labour and of the social-cultural systems that builds on previous generations in succession (Jonassen and Rohrer-Murphy 1999)
- Object-oriented: Human activity is not random, but it is always driven to achieve a desired objective, which is referred to as the object of activity (Kaptelinin 2005).
- Human activity is mediated: The assumption that humans do not interact with their environment in a direct way; instead, this interaction is mediated with help of instrumental means (Vygotsky 1981, Leont'ev 1977, 1978).
- Model of human behaviour: mediated activity between dyad parts is insufficient, resulting in the nature of human behaviour to be modelled as a triadic. The activity system is the simplest unit of analysis to model human behaviour capable of bridging together studies of micro and macro context (Engeström 1987).

Since there is no agreed methodology for the utilisation of AT, the educational researcher is presented with many decisions as the next immediate step in the operationalisation of the activity system's components. Seeing how the mathematics educational community has previously operationalised these components to the classroom may help to step forward the many decisions that the researcher needs to make.

Acknowledgements

This study is possible by funds from The Centenary Scholarship.

References

Barab, S., M. A Evans, and E. Beak. 2004. Activity theory as a lens for characterizing the participatory unit. In *Handbook of research on educational communications and technology: a project of the association for educational communications and technology*, edited by D. H. Jonassen. London: Routledge.

Coupland, M., and K. Crawford. 2006. Many dimensions : the complex picture of student encounters with a computer algebra system. Paper read at Mathematics Education Research Group of Australasia Conference, at Canberra Australia.

Engeström, Y. 1987. The emergence of learning activity as a historical form of human learning. In *Learning by expanding: an activity-theoretical approach to developmental research*: Orienta-Konsultit Oy.

———. 2001. Expansive Learning at Work: toward an activity theoretical reconceptualization. *Journal of Education and Work* 14 (1):133-156.

Engeström, Y., and R. Miettinen. 1999. Activity theory: A well-kept secret. In *Perspectives on Activity Theory*, edited by Y. Engeström, R. Miettinen and R. L. Punamäki-Gitai: Cambridge University Press.

Engels, F. *Dialectics of Nature*. International publishers, 2/11/2008 1940 [cited. Available from http://www.marxists.org

FitzSimons, Gail E. 2005. Technology mediated post-compulsory mathematics: an activity theory approach. *International Journal of Mathematical Education in Science and Technology* 36 (7):769-777.

Flavell, R. 2004. Developing activity theory for the learning of international students in Australia. Paper read at Australian Association for Research in Education (AARE) Conference, at Melbourne Victoria.

Groves, S., and J. Dale. 2005. Using activity theory in researching young children's use of calculators. Paper read at Australian Association for Research in Education (AARE) Conference, at Melbourne Victoria.

Hardman, J. 2005. An exploratory case study of computer use in a primary school mathematics classroom: New technology, new pedagogy? *Perspectives in Education* 23:4.

———. 2007. Making sense of the meaning maker: tracking the object of activity in a computer-based mathematics lesson using activity theory. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)* 3 (4):110-130.

Jaworski, Barbara. 2003. Research Practice into/Influencing Mathematics Teaching and Learning Development: Towards a Theoretical Framework Based on Co-Learning Partnerships. *Educational Studies in Mathematics* 54 (2-3):34-282.

Jonassen, David, and Lucia Rohrer-Murphy. 1999. Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research and Development* 47 (1):61-79.

Jurdak, Murad Eid. 2006. Contrasting Perspectives and Performance of High School Students on Problem Solving in Real World, Situated, and School Contexts. *Educational Studies in Mathematics* 63 (3):19-301.

Kanes, C. 2001. Numeracy as a cultural historical object. *Australian Vocational Education Review* 8 (1):43-51.

Koschmann, T., K. Kuutti, and L. Hickman. 1998. The Concept of Breakdown in Heidegger, Leont'ev, and Dewey and Its Implications for Education. *Mind, Culture, and Activity* 5 (1): 25-41.

Kaptelinin,V. and A. Nardi Bonnie. 1997. Activity theory: basic concepts and applications. In *CHI '97 extended abstracts on Human factors in computing systems: looking to the future*. Atlanta, Georgia: ACM.
Kuutti, K. 1996. Activity theory as a potential framework for human-computer interaction research. In *Context and Consciousness: Activity Theory and Human-Computer Interaction*, edited by B. A. Nardi: MIT Press.
Leont'ev, A. N. 1977. Activity and consciousness. *Philosophy in the USSR: Problems of*
Leont'ev, A. N., and M. J. Hall. 1978. Marxism and Psychological Science. In *Activity, consciousness, and personality*. Englewood Cliffs, NJ: Prentice-Hall
Lim, C. P., and D. Hang. 2003. An activity theory approach to research of ICT integration in Singapore schools. *Computers & Education* 41 (1):49-63.
Marx, K. *Theses on Feuerbach* Progress Publishers, 5/4/2009 1845 [cited. Available from http://www.marxists.org.
Roth, Wolff Michael, and Yew Jin Lee. 2004. Interpreting Unfamiliar Graphs: A Generative, Activity Theoretic Model. *Educational Studies in Mathematics* 57 (2):26-290.
Schurig, V. 1998. "Tätigkeit" or "Activity"? The Limits of Translating Key Psychological Concepts into other Languages. *Multidisciplinary Newsletter for Activity Theory* 1: 3-5.
Venkat, Hamsa, and Jill Adler. 2008. Expanding the foci of activity theory: accessing the broader contexts and experiences of mathematics education reform. *Educational Review* 60 (2):127-140.
Vygotsky, L. 1981. The Instrumental Method in Psychology. In *The Concept of Activity in Soviet Psychology*, edited by J. V. Wertsch. Armonk, New York: M.E. Sharpe, Inc.
Williams, J., and G. Wake. 2007. Black Boxes in Workplace Mathematics. *Educational Studies in Mathematics* 64 (3): 317-343.
Williams, Julian S., Geoff D. Wake, and Nick C. Boreham. 2001. School or college mathematics and workplace practice: an activity theory perspective. *Research in Mathematics Education* 3:69-83.
Zevenbergen, R., and S. Lerman. 2007. Pedagogy and interactive whiteboards: using an activity theory approach to understand tensions in practice. Paper read at Mathematics Education Research Group of Australasia (MERGA) Conference, at Hobart Tasmania.
Zurita, Gustavo, and Miguel Nussbaum. 2007. A conceptual framework based on activity theory for mobile CSCL. *British Journal of Educational Technology* 38 (2): 211-235.