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I have been investigating the process of producing mathematical knowledge with digital technologies for more than three decades. In various studies developed within our research group, Cultural-Historical Activity Theory (CHAT) has been used as a theoretical and analytical framework to understand the transformations that technologies cause in this process. In particular, this theory has made it possible to broaden our understanding of how human thinking is reorganized through interaction with digital technologies. Finding ourselves on the periphery of capitalism, we feel a responsibility not only to use theories but also to develop them. As some of us say, we believe that "voices from the South" should be heard.

The notion of reorganization of thinking, presented by Tikhomirov, an activity theorist, is one of the pillars of the humans-with-media construct, which we have been developing since the mid-1990s. It had its first main synthesis in 2005, by Borba and Villarreal. When we say "we", it's because this development is collective. Tikhomirov argued that computers have reorganized human thinking in a way qualitatively different from that of language. Lévy's idea of a thinking collective and the phenomenological approach that humans are "beings-in-the-world-with-others" are also at the genesis of this theoretical construct. The notion of dialogue, coming from Freire and his perspective on critical theory, is another pillar of the theoretical construct. The humans-with-media construct assumes that human and non-human actors (such as technologies) are mutually constituted in the production of knowledge. Both are agents that are intertwined in such a way that they form a collective that "thinks together." Knowledge is produced collectively by human and non-human beings.

The idea that media are co-producer agents of knowledge has gained strength from empirical studies carried out at the end of the 20th century and the beginning of the 21st century. Our research involving the production of mathematical knowledge in online environments pointed out that the Internet played the roles of artifact, community and subject in activity systems made up of students, teachers and digital technologies. This reinforces the argument that humans shape the technologies developed throughout history, but that media also shape human thought.

Through interaction, negotiation, and reflection, humans and media produce knowledge. From this perspective, “humans are constituted by technologies that transform and modify their reasoning and, at the same time, these humans are constantly transforming these technologies.” Thus, mathematics is seen as a historical and cultural product marked by different media.

Orality, writing, information technology and intelligence technologies are coproducers of the knowledge generated by humanity.

Two transformations have taken place in recent years. First, as we revisit Cultural-Historical Activity Theory (CHAT), it has led us to absorb the triangles of this theory, which allows us to discuss specifically learning. Second, we outline the idea of a possible fourth generation of activity theory – or a ramification of the third – as we break the rigidity of the triangles and see artifacts as subjects or community, as proposed by Souto and Borba. With a flexible perspective of the triangles, we can think of the humans-with-media construct as an activity system. Collectives of humans-with-media have rules, division of labor, subjects and objects transformed as new media, seen as having agency, are incorporated in an activity system. In this perspective, all the vertices of the triangle may have agency. We have, in our research, documented agency in several of these vertices. For example, we have documented how digital videos produced by students and teachers are seen as an activity system and how they may express social transformation and/or learning.

Recently, during the COVID-19 pandemic, the power of action of SARS-CoV-2 turned children's bedrooms or adults' dining rooms into classrooms. The sudden changes that occurred during the pandemic period led us to focus our discussions and reflections on the political role of the agency of artifacts such as homes in the collective that produces knowledge. Again, we used and recreated CHAT in order to attempt to understand mathematics education within this new context. Since then, we have been discussing various questions, including: "What is the role of non-human things, such as the virus and homes, in the way we know and learn mathematics? What is the role of math education in resisting inequality in the world? We believe that seeing humans connected to media in a strict sense (TV, computers, etc.) or in a large sense (virus, homes, etc.) help us to understand cultural and historical dynamics.

Our research Group (GPIMEM) is currently focusing on a variety of investigations on digital technology, many of them involving CHAT. We would like to highlight projects involving digital videos produced by collectives of teachers-students-with-different-media, and we are attempting to understand dangers and possibilities of artificial intelligence within this perspective. I thank José Fernandes Torres da Cunha for being part of "We" in the preparation of this profile.

Selected publications

Borba, M.C., Souto, D.L.P., Cunha, J.F.T., Domingues, N.S. (2023). Humans-with-Media: Twenty-Five Years of a Theoretical Construct in Mathematics Education. In: Pepin, B., Gueudet, G., Choppin, J. (eds) Handbook of Digital Resources in Mathematics Education. Springer International Handbooks of Education. Springer, Cham. https://doi.org/10.1007/978-3-030-95060-6_7-1

Borba MC (2021, April 27) The future of mathematics education since COVID-19: humans-withmedia or humans-with-non-living-things. Educ Stud Math:385–400. https://doi.org/10.1007/s10649-021-10043-2

Borba MC, Villarreal ME (2005) Humans-with-media and the reorganization of mathematical thinking: information and communication technologies, modeling, visualization and experimentation. Springer US

Souto DLP, Borba MC (2018) Humans-with-internet or internet-with-humans: a role reversal? (Reprint). RIPEM 8(3):2–23