IASCUD Activity Report 2024

During the past year, the International Association for Science and Cultural Diversity (IASCUD) organized and held one symposium, “Formal Systems as Cognitive Tools in the History of Math and Science,” at the [XXXI Baltic Conference on the History and Philosophy of Science](). The theme of the conference was, Scientific Instruments in History and Philosophy of Science, Technology and Medicine. The conference was hosted by the University of Tartu, Estonia, 13-15 June 2024. Although we had originally planned for more than three speakers, the resulting panel and discussion was lively, productive, and resulted in recruiting new members to IASCUD. Since no participants in this year’s symposium were early career researchers, we did not fund anyone’s travel to Estonia.

Symposium Abstract: From Francis Bacon’s observations about *machina intellectus*, or machines designed to aid the understanding, to more recent cognitive science inquiries into the “scaffolding” role played by formal systems of signification in knowledge acquisition (Larvor 2020), philosophers, historians, and educators have sought to better understand how symbolic notations and formal methods help individuals and communities learn new things and make new experiences possible. The project of understanding how cognitive tools help scientific understanding grow has led to a careful consideration of how artifactual practices of scientists and mathematicians make implicit features of the natural world explicit. For example, Menary (2015, 4) argues: “Practices govern how we deploy tools, writing systems, number systems, and other kinds of representational systems to complete cognitive tasks. These are not simply static vehicles that have contents; they are active components embedded in dynamical patterns of cultural practice.” The goal of this panel is to consider case studies in the growth of knowledge that show how social and enculturated beings wield representational and inferential strategies to make communities of consensus possible.

Madeline Muntersbjorn, IASCUD president and associate professor at the University of Toledo, presented “Cognitive Tools in the Algebra Project.” The Algebra Project (AP) was founded by Bob Moses (1935–2021) to teach algebra to adolescents. The AP defines mathematical literacy as the ability to speak the languages of mathematics fluently: “At the Algebra Project, we believe that in the 21st century every child has a civil right to secure math literacy—the ability to read, write and reason with the symbol systems of mathematics” (www.algebra.org). AP pedagogy is based on a five-step learning progression that starts from (1) a shared experience that (2) students represent in drawings before (3) comparing their experiences and drawings with each other, and from these conversations (People Talk), (4) students learn to speak more regimented discourses (Feature Talk) that make implicit mathematical features of their experiences explicit. According to Moses et al. (1989, 433), “The purpose of the five steps is to avert student frustration in ‘the game of signs,’ or the misapprehension that mathematics is the manipulation of a collection of mysterious symbols and signs.” A common impediment to mathematical understanding is the expectation that the same signs will always refer to the same things when two opposing tendencies may be found throughout mathematics, both “the art of giving the same name to different things,” as Poincaré noted, as well as the art of giving different names to the same things. This paper approaches AP pedagogy through the lens of the enculturation theory which suggests that dynamic group interactions with cognitive tools, including diagrams and symbols, transform how we think.

Peeter Müürsepp, IASCUD assessor and associate professor at Tallinn University of Technology, presented "Leibniz and the Calculus Notation." The dispute over the priority of creating calculus is well known. Initially, the controversy was about the timing only. Needless to say, applying acceptable notation has also become part and parcel of the story. Leibniz paid special attention to the symbols used in maths and logic, believing that they are important for human understanding, that the role of symbols is essential for a kind of automated knowledge. The attitude of Leibniz stems from his general idea that he worked into the characteristica universalis, which he understood as an alphabet for human thinking. Leibniz imagined a formal language that could express abstract mathematical and scientific as well as metaphysical ideas. He believed that by combining simple representations of thoughts, one can build some level of complexity through abstraction. These general considerations helped Leibniz a lot in his contributions as an originator in mathematics. For him, it was not just important to innovate maths for the mathematicians but also to make the novel developments understandable and acceptable from the applications point of view. To fulfil this task, it was vital for Leibniz to pay special attention to the notation, the symbols he introduced. Especially, his notation was connected to original contributions. Leibniz introduced the integral sign we know (∫), representing an elongated S, from its Latin word summa, and the operator d used for differentials, from the Latin word differentia. The notations introduced by Leibniz made the concepts of calculus transparent. Thus, we can say that although Leibniz was the winner over Newton in terms of the notation, he failed to achieve a priority in time due to delaying publishing his works on the new method.

Amirouche Moktefi, senior lecturer at Tallinn University of Technology, presented "On Scaffolding and Mathematical Representations." The scaffolding metaphor is commonly used in educational psychology to convey a temporary support for the learner to complete a task which she could not achieve otherwise. It has been suggested that mathematical representations can be regarded as a scaffolding of this sort, enabling us to conduct calculations and reasonings which could not be conducted without them. This view (and the metaphor itself) has recently been criticised on the ground that "scaffolding in good order is immobile, temporary, and crude. Mathematical representations can be manipulated, are not temporary structures to aid development, and are refined" (Larvor 2020). In our talk, we consider the arguments at hand and argue that it is possible to identify a variety of practices in which mathematical representations are used in mathematics and mathematical education, and some (at least) are adequately characterised by the scaffolding metaphor. Incidentally, we show that the metaphor has been used by mathematicians themselves prior to its occurrence in educational psychology and cognitive sciences. We also discuss some examples of scaffolding practices in the history of mathematics education and what they teach us on the role of mathematical representations.

Panel References:

Menary, Richard. 2015. "Mathematical Cognition—A Case of Enculturation." In *Open MIND*: 25(T), edited by T. Metzinger and J. M. Windt. Frankfurt am Main: MIND Group.

Larvor, Brendan. 2020. "Why 'Scaffolding' is the Wrong Metaphor: The Cognitive Usefulness of Mathematical Representations." *Synthese* 197, 3743–56.

Moses, Robert, Mieko Kamii, Susan McAllister Swap, and Jeffrey Howard. 1989. "The Algebra Project: Organizing in the Spirit of Ella." *Harvard Educational Review* 59 (4), 423– 44.