Geometry comes back to senses: Collaborative construction of tangible models

Alik Palatnik
The Hebrew University of Jerusalem, Seymour Fox School of Education,
alik.palatnik@mail.huji.ac.il

Abstract

Educational scholars agree that geometry learning is especially suitable for development of different reasoning styles, inquiry and problem-solving skills and rigor. However, current geometry curriculum fails to realize this potential for many students. Historically, geometry education is focused on manipulations with relatively small objects situated in flat and static mediums, by the solitary agent relying, among her senses, only on vision. Moreover, the prevailing paradigm is of learner's information processing separating senses and actions from thinking.

In contrast, embodied cognition theories perceive bodily interactions with the environment as a primary source for cognitive structures. Embodied learning (EL) supports primacy of students' enactment of conceptually oriented movement forms and gradual formalization of gestures and actions in disciplinary formats. EL is rooted in an ecological approach in cognitive psychology (Gibson, 1986/2015), capitalizing on organism-environment relations.

An embodied approach to geometry presented in this session capitalizes on a material application of constructive and multimodal approach to learning. Learners construct not mental models but physically available objects that become parts of their thinking and provide ways for formalization based on physical experiences allowing improved functioning in the 3D world.

The session combines a collaborative mathematical activity of construction and exploration of tangible models and presentation of empirical results and theoretical underpinnings concerning the activity. The analytical apparatus of Mason's shifts of attention theory facilitates investigation of why and how using physical models can facilitate learning of (spatial) geometry. Learners' critical insights are characterized as shifts in the focus and structures of perceptuomotor attention leading to refinement of geometric argumentation. Students' realization of an available 3D medium affordances catalyzes these shifts. Construction and exploration of tangible models create need for collaboration and facilitate productive exchange of perspectives between the participants. The findings contribute to a socio-material elaboration of embodied learning for school geometry.

and with tenets of embodied design for mathematics instruction (Abrahamson et al., 2020)

In particular, Gibson conceived perception as an active, embodied process in which we notice optical invariances of the object under the movement of the source of light, movement of the observer, movement of an observer's head, and manipulations and local transformations of the object itself.

Students facing tasks in realistic 3D contexts can be introduced to the language of geometry, its objects and constructions (Doorman et al., 2020).

Several scholars suggested that mathematical modeling of geometric figures should take into account four distinct perceptual systems of the figure(s): (a) as physical navigation of macrospace (objects more than 50 times the size of an individual); (b) as capturing an object in mesospace (0.5 to 50 times); (c) as constructions of small objects in microspace (less than 0.5 times); and (d) as descriptions and manipulations of small objects in microspace (e.g. Herbst et al., 2017).

Still, why and how physical models of different scales can facilitate learning of (spatial) geometry remains an open question. This empirical study seeks to provide an answer using the analytic apparatus of Mason's shifts of attention theory.