
References


Blind Students, Special Needs, and Mathematics Learning

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Keywords

Blind mathematics learners; Perception and cognition; Visualization; Auditory representations; Tactile representations

Characteristics

Blindness, in itself, does not seem to be an impediment to learning mathematics. Indeed, history shows that there have been a number of very successful blind mathematicians, perhaps the most well known being Euler (1707–1783), who became blind in the latter part of his life, and Saunderson (1682–1739) who lost his sight during his first year. Jackson (2002), in his consideration of the work of these and more contemporary blind mathematicians, suggests that the lack of access to the visual field does not diminish a person’s ability to
visualize – but modifies it, since spatial imagination amongst those who do not see with their eyes relies on tactile and auditory activity. This would suggest that to understand the learning processes of blind mathematics learners, it is important to investigate how the particular ways in which they access and process information shapes their mathematical knowledge and the learning trajectories through which it is attained.

Vygotsky’s work with disabled learners, in general, and those with visual impairments, in particular, during the 1920s and 1930s represented an early attempt to do just this. Rather than associating disability with deficit and focusing on quantitative differences in achievements between those with and without certain abilities, he proposed that a qualitative perspective should be adopted to research how access to different mediating resources impacts upon development (1997). The key to understanding and supporting the practices of blind learners, he argued, lies in investigating how the substitution of the eyes by other tools both permits and shapes their participation in social and cultural activities, such as mathematics learning.

For the study of mathematical topics that involve working with spatial representations and information, the hands represent the most obvious substitute for the eyes, and hence it is not surprising that research involving blind geometry learners has focused on how explorations of tactile representation of geometrical objects contribute to the particular conceptions that emerge. While vision is synthetic and global, with touch the whole emerges from relationships between its parts, a difference which Healy and Fernandes (2011) suggest might explain the tendency amongst blind learners to describe geometrical properties and relations using dynamic rather than static means, which simultaneously correspond to and generalize their physical actions upon the objects in question.

Hands also play an important role in blind students’ access to written materials, with Braille codes substituting text in documents for blind readers. There are, however, a number of particular challenges associated with learning and doing mathematics using Braille. First, there is no one universally accepted Braille code for mathematics, with different notations used in different countries. The coding systems are complex and can take considerable time to master (Marcone and Penteado 2013). An additional complication is that Braille is a strictly linear notation, whereas conventional mathematical notations make use of visual features – fractions provide a case in point. The linear versions of conventional notations require additional symbols, making expressions in Braille lengthy; compounded by the fact that Braille readers can only perceive what is under their fingers at a particular moment in time, it can be very difficult for them to obtain a general view of algebraic expressions. Digital technologies are facilitating conversions between Braille and text and offering the blind learner spoken versions of written mathematics, but research is needed to investigate how such alternative notation forms might impact differently on mathematical understandings and practices.

Use of spoken rather than written materials suggests that the ears can also be used as substitutes for the eyes. But auditory learning materials need not be limited to speech. Leuders (2012) argues that auditory perception represents an important modality for processing mathematical structures that has been under-explored. Here, too, digital technologies are bringing new forms of representing and exploring mathematical objects; one example is a musical calculator which enables students to hear as well as see structures of rational and irrational numbers (Fernandes et al. 2011).

In short, although the practice of blind mathematics learners is a topic that has been relatively under-researched in the field of mathematics education, the evidence that does exist suggests that in the absence of the visual field, information received through other sensory and perceptual apparatuses provides alternative forms of experiencing mathematics. Deepening our understandings of how those who do not see with their eyes learn and do mathematics may hence contribute to furthering our understanding of the relationships between perception and mathematical cognition more generally.
Bloom’s Taxonomy in Mathematics Education

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Keywords
Cognition; Evaluation; Educational objectives; Student achievement; Assessment

Definition
An approach to classifying reasoning goals with respect to mathematics education.

Overview
Bloom’s Taxonomy is arguably one of the most recognized educational references published in the twentieth century. As noted in a 40-year retrospective by Benjamin Bloom (1994), “it has been used by curriculum planners, administrators, researchers, and classroom teachers at all levels of education” (p. 1), and it has been referenced in academic publications representing virtually every academic discipline. Given the prevalence of testing in mathematics and the regular use of mathematics as a context for studying student reasoning and problem solving, Bloom’s Taxonomy has been applied and adapted by mathematics educators since its publication.

Historical Development
Originally designed as a resource to support the development of examinations, Bloom et al. (1956) wrote their taxonomy to insure greater accuracy of communication among educators in a manner similar to the taxonomies used in biology to organize species of flora and fauna. The ubiquitous reference to Bloom’s Taxonomy is a triangle with six levels of named educational objectives for the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation (Fig. 1; Office of Community Engagement and Service 2012).

Because of this reductivist use of Handbook 1: Cognitive Domain in which the taxonomy appeared (Bloom et al. 1956), few will recall that the knowledge category included multiple “knowledge of” subcategories such as knowledge of conventions, knowledge of trends and sequences, and knowledge of methodology. The writing team recognized that even knowledge ranges in complexity and is quite nuanced and detailed in ways that belie its perfunctory contemporary placement on the base of the