► Immigrant Students in Mathematics Education
► Language Background in Mathematics Education
► Language Disorders, Special Needs and Mathematics Learning
► Mathematical Language
► Mathematical Representations
► Semiotics in Mathematics Education

References

Adler J (1998) A language of teaching dilemmas: unlocking the complex multilingual secondary mathematics classroom. Learn Math 18(1):24–33

Barton B, Fairhall U, Trinick T (1998) Tikanga reo tatai: issues in the development of a maori mathematics register. Learn Math 18(1):3–9

Barwell R (2003a) Linguistic discrimination: an issue for research in mathematics education. Learn Math 23(2):37–43

Barwell R (2003b) Patterns of attention in the interaction of a primary school mathematics student with English as an additional language. Educ Stud Math 53(1):35–59

Barwell R (2008) Discourse, mathematics and mathematics education. In: Martin-Jones M, de Mejia A-M, Hornberger N (eds) Encyclopedia of language and education, (2nd edn., Vol. 3). Discourse and Education. Springer, New York, pp 317–328

Barwell R (ed) (2009) Multilingualism in mathematics classrooms: global perspectives. Multilingual Matters, Bristol

Barwell R, Barton B, Setati M (2007) Multilingual issues in mathematics education: introduction. Educ Stud Math 64(2):113–119

Bialystok E (2001) Bilingualism in development: language, literacy and cognition. Cambridge University Press, Cambridge, UK

Clarkson PC, Galbraith P (1992) Bilingualism and mathematics learning: another perspective. J Res Math Educ 23(1):34–44

Cocking R, Mestre J (eds) (1988) Linguistic and cultural influences on learning mathematics. Lawrence Erlbaum, Hillsdale, pp 221–240

Cummins J (2000) Language, power, and pedagogy. Multilingual Matters, Buffalo

Dawe L (1983) Bilingualism and mathematical reasoning in English as a second language. Educ Stud Math 14(4):325–353

Grosjean F (1999) Individual bilingualism. In: Spolsky B (ed) Concise encyclopedia of educational linguistics. Elsevier, London, pp 284–290

Kazima M (2007) Malawian students' meanings for probability vocabulary. Educ Stud in Math 64(2):169–189

Mercado J (2010) Code switching. In: Encyclopedia of cross-cultural school psychology. Springer US, Berlin, pp 225–226

Moschkovich J (2002) A situated and sociocultural perspective on bilingual mathematics learners. Math Think Learn 4(2–3):189–212

Moschkovich JN (2007) Using two languages while learning mathematics. Educ Stud Math 64(2):121–144

Moschkovich JN (2010) Language and mathematics education: multiple perspectives and directions for research. Information Age Publishing, Charlotte

Peña E, Bedore L (2010) Bilingualism. In: Clauss-Ehlers C (ed) Encyclopedia of cross-cultural school psychology, vol 2. Springer Verlag, Berlin

Roberts T (1998) Mathematical registers in aboriginal languages. Learn Math 18(1):10–16

Setati M (1998) Code-switching and mathematical meaning in a senior primary class of second language learners. Learn Math 18(1):34–40

Valdés-Fallis G (1978) Code switching and the classroom teacher. In: Language in education: theory and practice, vol 4. Center for Applied Linguistics, Wellington

Blind Students, Special Needs, and Mathematics Learning

Lulu Healy and Solange Hassan Ahmad
Ali Fernandes
Programa de Pós Graduação em Educação
Matemática, Universidade Bandeirante
Anhanguera, São Paulo, Brazil

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.

Cross-References

▶ Deaf Children, Special Needs, and Mathematics Learning
▶ Equity and Access in Mathematics Education
▶ Inclusive Mathematics Classrooms
▶ Mathematical Representations
▶ Political Perspectives in Mathematics Education
▶ Psychological Approaches in Mathematics Education
▶ Visualization and Learning in Mathematics Education

References

Fernandes SHAA, Healy L, Martins EG, Rodrigues MAS, Souza FR (2011) Ver e ouvir a Matemática com uma calculadora colorida e musical: estratégias para incluir aprendizes surdos e aprendizes cegos nas salas de aulas. In: Pletsch MD, Damasceno AR (eds) Educação Especial e inclusão escolar: reflexões sobre o fazer pedagógico. EDUR = Editora da Universidade Federal do Rio de Janeiro, Seropédica, pp 97–111

Healy L, Fernandes SHAA (2011) The role of gestures in the mathematical practices of those who do not see with their eyes. Educ Stud Math 77:157–174

Jackson A (2002) The world of blind mathematicians. Not Am Math Soc 49(10):1246–1251

Leuders J (2012) Auditory teaching material for the inclusive classroom with blind and sighted students. In: Proceedings of the 12th international congress on mathematical education, Seoul

Marcone R, Penteado MG (2013) Teaching mathematics for blind students: a challenge at the university. Int J Res Math Educ 3(1):23–35

Vygotsky L (1997) Obras escogidas V–Fundamentos da defectología [The fundamentals of defectology] (trans: Blank JG). Visor, Madrid

Bloom's Taxonomy in Mathematics Education

David C. Webb
School of Education, University of Colorado Boulder, Boulder, CO, USA

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