Cite as: Jones, K. (2005), Using Logo in the Teaching and Learning of Mathematics: a research bibliography, *MicroMath*, 21(3), 34-36.

Using *Logo*

in the Teaching and Learning of Mathematics:

a research bibliography

Keith Jones

Of the ways in which ICT can provide powerful learning opportunities for students studying mathematics, "teaching the computer" remains one potent means for students to experience being creative with their mathematics. There are various ways in which students can get experience of "teaching the computer". One significant route, and one that has been the subject of considerable research attention, is the use of *Logo*, a programming language specifically designed with the learner in mind. Aspects in common to most versions of *Logo* include the entry point for learners being a "graphics" window and control of an on-screen cursor usually referred to as a "turtle" (thus users are immediately in a visual

thinking/geometrical environment) and the setting that *Logo* provides for problem solving and problem posing.

The aim of this research bibliography is to record the main themes and findings of research into the use and impact of *Logo* on mathematics teaching and learning.

Dating back to the 1970s, research on *Logo* has spanned both geometry and algebra, examining pupils' learning of various aspects of mathematics, especially angles and shape, ideas of variable and forms of algebraic notation, notions of recursion, and the use of problem-solving strategies.

Overall, the body of research suggests that students working with *Logo*, by creating and interacting with objects that are visible, quantifiable, and adhere to conventional mathematics, build connections between spatial and numeric/algebraic thinking. Using *Logo* can help students make mathematics more concrete, while simultaneously supporting algebraic formalisation of actions as *Logo* "procedures". Working with *Logo* affords students opportunities to try out ideas and modify plans, elements that are key to mathematical problem solving. Students can make and test conjectures, a vital component of mathematical reasoning.

Research, as it should, has also pointed to issues that need to taken into account in the classroom. For example, pupils can become centred on the screen product at the expense of reflection upon its construction and may modify a figure "to make it look right" rather than debug the construction process; pupils do not necessarily mobilise their geometric and algebraic understandings in the computer context such that manipulation of screen images does not necessarily mean that the conceptual ideas are fully appreciated.

Being aware both of the benefits of using *Logo*, and of the potential problems, should help to accentuate student learning.

Rather than select out a limited number of research reports within the space available for this bibliography, the publications listed below (presented in chronological order of publication) record the beginnings of *Logo*, together with a sample of later books and research reviews and reports. These should provide leads to the large amount of research on using *Logo*.

Papert, S. (1970). *Teaching Children Thinking* (AI Memo No.247 and Logo Memo No. 2). Cambridge, MA: MIT Artificial Intelligence Laboratory.
This title sums up Papert's starting point.

Papert, S. (1972), Teaching Children to be Mathematicians versus Teaching about Mathematics, *International Journal of Mathematical Education in Science & Technology*, **3**(3), 249-262.
Reprinted in: Taylor, R. P. (Ed.) (1980), *The Computer in School: tutor, tool, tutee*. New York: Teachers College Press; and in: Floyd, A (ed) (1981) *Developing Mathematical Thinking*. Wokingham: Addison-Wesley.
Seminal paper arguing for *Logo*-type experiences for learners of mathematics.

Papert, S., Watt, D., di Sessa, A., & Weir, S. (1979).*Final Report of the Brookline Logo Project: Parts 1 and 11* (Logo Memos Nos. 53 and 54). Cambridge, MA: MIT Artificial Intelligence Laboratory.
More evidence for *Mindstorms*.

Papert, S. (1980), *Mindstorms: children, computers, and powerful ideas*. New York: Basic Books.
A mindstorm of a book demonstrating how a strong philosophical underpinning can put learners in control of technology (in this case, via *Logo*). Still a good read and still able to storm minds.

Clements, D. H. (1985), Research on Logo in Education: is the turtle slow but steady, or not even in the race? *Computers in the Schools*, **2**(2&3), 55-71. [special edition on L*ogo* edited by Papert]
Early review recognising that despite positive predictions, research results had yet to delineate a clear picture of the impact of *Logo* experiences on student cognitive development.

Weir, S. (1987). *Cultivating minds: a Logo casebook*. New York: Harper and Row.
Pioneering study documenting the effectiveness of using *Logo* to help develop learning strategies for children with severe learning disabilities. Coined the idea that a computer environment like *Logo* can provide a "window on the mind".

Hoyles, C., & Sutherland, R. (1989), *Logo Mathematics in the Classroom*. London: Routledge.
Pioneering classroom study full of amazing student achievements that demonstrate what is possible when learners of mathematics have some say in what they learn, and, importantly, have the tools at hand to put their ideas into practice. [a 2nd edition was published in 1992]

Hoyles, C. and Noss, R. (Eds) (1992), *Learning Mathematics and Logo*. Cambridge, Mass.: MIT Press.
Authoritative collection of articles, both looking back at what existing research had achieved (to that point) and looking forward to researching "the potential for mathematics learning inherent in Logo".

Clements, D. H., and Sarama Meredith. J (1993), Research on Logo: effects and efficacy, *Journal of Computing in Childhood Education*, **4**(4), 263-290.
Valuable overview of more than 70 papers published in the 70s and 80s. Concludes that while it appears that there are no "guaranteed results", use of *Logo* has the potential to improve students' educational experience of mathematics.

Yelland, N. (1995), Mindstorms or a storm in a teacup? A review of research with Logo. *International Journal of Mathematical Education in Science & Technology*, **26**(6), 853-869.
Useful review of around 80 major studies of the use of *Logo* in mathematics teaching and learning.

Maddux, C. D. and Johnson, D. L (eds) (1997), *Logo, a retrospective*. New York: Haworth Press. Also published as a special issue of the journal *Computers in the Schools*, volume 14, numbers 1&2.
Contains a range of useful articles, including a review of research on *Logo* by Clements and Sarama covering almost 200 studies.

Clements, D. H., Battista, M. T. with Sarama, J. (2001), *Logo and Geometry: JRME monograph number 10*. Reston, Va.: National Council of Teachers of Mathematics.
Detailed account of the four year development and implementation of an elementary school geometry curriculum that "addresses the deficits of the current curriculum"; carefully describes the theoretical basis for the curriculum, how pupils learn geometric concepts, and how using *Logo* impacts on this.

Papert, S. (2002), The Turtle's Long Slow Trip: macro-educological perspectives on Microworlds, *Journal of Educational Computing Research*, **27**(1&2), 7-28.
Concludes with Papert's observation that "the slow pace of the [*Logo*] turtle's progress into the school world may only reflect the sluggish transition of School to the new media".

Micromath *Research Bibliographies*

Every year, hundreds of teachers engage in classroom-based research for a variety of purposes. As more and more opportunities arise for teachers to get support for engaging with research, *Micromath* is devoting a section to a series of *research bibliographies* designed to provide details of the most pertinent research on using particular ICT applications in the teaching and learning of mathematics. Previous bibliographies are:

Graphing Calculators in the Teaching and Learning of Mathematics: a research bibliography, *Micromath*, **21**(2), 31-33.

Using Spreadsheets in the Teaching and Learning of Mathematics: a research bibliography, *Micromath*, **21**(1), 30-31.

Using Interactive Whiteboards in the Teaching and Learning of Mathematics: a research bibliography, *Micromath*, **20**(2), 5-6.

Celebrating 20 Years of Computers in Mathematics Education: a research bibliography, *Micromath*, **20**(1), 29-30.

Using the Internet in the Teaching and Learning of Mathematics: a research bibliography, *Micromath*, **19**(2), 43-44.

Research Bibliography: Four-function Calculators, *Micromath*, **19**(1), 33-34.

Research Bibliography: Dynamic Geometry Software, *Micromath*, **18**(3), 44-45.

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