



UNIVERSITY
OF ABERDEEN

Why multiple representations? – What research says

Allan Duncan

Honorary Senior Lecturer in Mathematics Education

University of Aberdeen

Scotland

UK



SCHOOL OF EDUCATION

Why multiple representations? – What research says

Mathematical concepts may be **represented** in many different ways

These **multiple representations** may be

- algebraic - an expression or an equation
- numerical - a table of values
- graphical
- geometrical/diagrammatical
- physical – ‘walking a graph’
- linguistic



Why multiple representations? – What research says

Duval (2006)

- semiotic systems of representation may be used to designate, communicate, work on or work with the mathematical objects being represented
- calls each representation a 'register'
- argues that **mathematical activity is the simultaneous use of at least 2 registers** or the conversion ('transformation') from one to another
- **comprehension depends on coordination of several representation registers**
- "standard teaching" rarely focuses on the recognition of a mathematical object across registers



Why multiple representations? – What research says

Brenner et al. (1997) argue that students can be successfully taught both to represent function problems in multiple representations and to translate between these representations

Kieren (1993) places emphasis on the integration of various representations

Williams (1993) highlights the importance of being able to move comfortably between and among these three different representations

Adu-Gyamfi (2002) found that students experiencing multiple representations type instruction demonstrated deeper understanding of mathematical concepts



Why multiple representations? – What research says

Multiple representations and the use of ICT

Burrill et al. (2002) argue that teachers who **emphasize connections among representations** and sense making in working with both the mathematics and the tool (graphing calculator) see the results in the **improved performance** of their students and

that students using handheld technology are more flexible in their solution strategies, make conjectures and move more comfortably among algebraic, numeric and graphical approaches (**Ruthven, 1990, Hollar & Norwood, 1999**)



Why multiple representations? – What research says

Multiple representations and the use of ICT

Research focused in particular on the use of **dynamically linked multiple representations** has found that students learn concepts more readily when they experience them across different forms of notation and representation (**Davis & Maher**, 1997, **Kaput**, 1992, **Kaput et al.**, 2002)

Small-scale studies indicate that a **multiple representation approach** can produce gains in **deep mathematical understanding** (**Roschelle et al.**, 2000).



Why multiple representations? – What research says

Multiple representations and the use of ICT

Hegedus & Kaput (2007) emphasize the power of **linking representations dynamically**, so that students can see how one representation changes when others do and argue that

“it also **builds connections** between principles and concepts which are **often taught in isolation** (sometimes years apart, in conventional curricula). The ability to move easily across a connected network of knowledge, and to change representation systems, is critical to high-level problem solving when doing “real” mathematics and science.” (My bold!)



Why multiple representations? – What research says

Multiple representations and the use of ICT

Burrill et al. (2002) are acutely aware that the use of handheld technology is not a single variable which can be easily isolated but is **part of a very complex teaching and learning environment** where a great number of factors are intertwined and inter-related.

Farrell (1996) concluded that there was a tendency for the technology use to help teachers to shift their classroom activity such that there was **less teacher exposition** and **more student investigation**.



Teachers' Views in 66 lesson evaluations

*"In your view, did **the use of multiple representations** with TI-nspire **enhance students' relational understanding of the mathematics involved** in this lesson or not?"*

YES	80%
NO	3%
Undecided	12%



Comments on multiple representations

Comments (Total 105)	%
Evidence detailing specific use of multiple representations	33
Evidence detailing verbal or written responses from pupils	13
Evidence of improved discussion	12
Evidence of 'aha' moments – 'seeing' pupils' understanding	12
Evidence of improved retention	10
Evidence believed by teacher to be inconclusive	8



Issues for consideration or further investigation

- Are teachers conscious of changing the way they teach particular topics?
- Are teachers conscious of changing the way they teach in general?
- In what ways is learning and teaching changing as a result of using software plus handhelds?



Teachers' Views in 66 lesson evaluations

“Were you conscious of changing the way you teach this topic?”

YES	79%
NO	15%
Undecided	5%



Research on Teachers' Views on Impact of Multiple Representations Technology on Students' Understanding of Mathematics – A G Duncan

“Were you conscious of changing the way you teach this topic?”

Comment	%
Changing the way I teach this topic	42
Evidence of more active involvement from pupils	20
Evidence of links across maths topics	10
More opportunity for more open questioning and discussion	6
Teaching topics earlier than normal	5



Research on Teachers' Views on Impact of Multiple Representations Technology on Students' Understanding of Mathematics – A G Duncan

“Were you conscious of changing the way you teach in general?”

Comment	%
Allows students more freedom to investigate possibilities	28
Conscious of changing classroom dynamics	13
Allowing/encouraging more discussion with and amongst students	13
Consciously making an effort to link topics together	11
Consciously aiming to improve/deepen students' understanding	9



Other Issues

Which Curriculum for Excellence **indicators** are apparent when using the technology?

(Curriculum for Excellence is a new initiative in Scottish Education)



SCHOOL OF EDUCATION

Research on Teachers' Views on Impact of Multiple Representations Technology on Students' Understanding of Mathematics – A G Duncan

Percentages of 66 lesson evaluations

	Curriculum for Excellence Indicators	%
Successful Learners	Enthusiasm and motivation for learning	91
	Determination to reach high standard of achievement	50
	Openness to new thinking and ideas	82
	Use literacy, communication and numeracy skills	62
	Use technology for learning	100
	Think creatively and independently	58
	Learn independently and as part of a group	74
	Make reasoned evaluations	74
	Link and apply different kinds of learning in new situations	56



SCHOOL OF EDUCATION

References 1

Duncan, A. G. (2010). *Teachers' views on dynamically linked multiple representations and relational understanding of mathematics – an investigation into the use of TI-Nspire in Scottish secondary schools*. Aberdeen: University of Aberdeen

http://www.abdn.ac.uk/education/documents/UofA_Report_Mar10.pdf

Duncan, A.G. (2010) *Inspired Connections in Maths Lessons*. Aberdeen: University of Aberdeen

http://www.abdn.ac.uk/education/documents/Inspired_Connections_web.pdf



SCHOOL OF EDUCATION

References 2

Duncan, A. G. (2010). Teachers' views on dynamically linked multiple representations, pedagogical practices and students' understanding of mathematics using TI-Nspire in Scottish secondary schools. *ZDM International Journal on Mathematics Education* 42:763-774

<http://www.springerlink.com/content/p4787841x2219856/>



SCHOOL OF EDUCATION

Contact details

Allan Duncan BSc MEd FHEA

Hon Snr Lecturer in Mathematics Education

School of Education

University of Aberdeen

Scotland, UK

a.g.duncan@abdn.ac.uk



SCHOOL OF EDUCATION