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PART 1

Refereed research reports which were written for the seventh BCME conference and presented at the conference.

Analysis of classroom interaction from the combined view of self-regulating strategies and discourse analysis: What can we learn?

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The purpose of this study is to investigate the relationship between self-regulated learning (SRL) and mathematical discourse. The study involved a group of Year 9 students in the East of England engaged in mathematical tasks. Analysis on the students' interactions was carried out employing two types of analytical tools: Pintrich's (1999) model of self-regulated learning strategies, with particular attention to the rehearsal strategies, and Sfard and Kieran's (2001) discourse analysis framework. The findings show the emergence of key mathematical concepts during the engagement with SRL strategies have positive impact in producing an effective and productive discourse among the group members.

The Primary Mathematics Specialists – What Do They Think About Teaching and Learning Mathematics?

Barbara Allen

The Open University

One recommendation of the Williams Review (2008) was that there should be a Primary Mathematics Specialist in every primary school within the next ten years. Research with one group of over 100 primary teachers following an Open University course suggests that the teachers who will be following the Primary Mathematics Specialists Programme will face a number of challenges including changes to their beliefs about the importance of subject knowledge and their pedagogic practices.

Acknowledging the cultural dimension in research into mathematics teaching and learning

Paul Andrews

University of Cambridge

In this review paper I make a plea for those involved in research into the teaching and learning of mathematics to acknowledge that however their work is framed, it will be located in a culture, not always visible to their readers, that needs making explicit. In order to do this I first examine three key models of culture and their significance for education. Secondly I consider various models of curriculum and ways in which school mathematics is presented. Finally, I summarise some recent comparative research in mathematics teaching showing substantial variation in the ways in which teachers manage the presentation of mathematics in their classrooms. In so doing a plea to researchers is framed: Culture permeates all aspects of educational endeavour and should be acknowledged more explicitly than it is.

Can Australians Mark KS3 Mathematics Exams? A Study in Cultural

Differences

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Highly experienced Australian teachers ($N = 38$) marked a sample of the 2006 KS3 mathematics exams, following similar training to their counterparts in the United Kingdom. Results indicated that were able to mark at a very high standard, but experienced a number of difficulties in doing so. Marking diaries revealed that a number of cultural differences existed concerning quality control, the number of questions marked, the different emphases attached to calculation accuracy, mathematical processes and conceptual understanding.

Developing a leading identity across the transition to mathematically demanding programmes at university

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In a previous paper (Black et al. 2010) we drew on interview data with AS level mathematics (post-16) students to present the concept of 'leading identity' which, we argued, defines the student's motive for study and shapes their relationship with mathematics. We argued that whilst some students might focus on a leading identity of 'being a student' and thus, engage with the activity of 'studying' merely to gain qualifications, others focus upon 'studying' with a vocational future in mind and thus attend to the 'use value' of mathematical knowledge beyond the institution of schooling. In that paper, we presented the story of Mary, a student studying AS level Use of Maths, who had a leading identity of 'becoming an engineer'. We argued that this leading identity gave her enough motivation to persist in studying

mathematics where others might have dropped the subject. In this paper, we wish to explore the sustainability of this leading identity for Mary as she experiences transition from college to university. We now have five interviews with Mary which cover the period from the start of her AS level studies to the end of her one year Foundation Degree in Mechanical Engineering at university. In telling Mary's transitional story, we ask: how does Mary experience transition in light of her 'leading identity'? And how does this affect her relationship with mathematics? Furthermore, we also seek to understand how Mary's transitional story is positioned within the landscape of cultural narratives about transition available to her.

Research and Developments in Probability Education Internationally

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In the topic study group on probability at ICME 11 a variety of ideas on probability education were presented. This paper provides a brief summary of the main threads of research in probability education across the world; it is intended that this will help consolidate developments. Further areas for work and research are also presented.

The struggle to achieve multiplicative reasoning 11-14

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Multiplicative reasoning is a key competence for many areas of employment and everyday life, and for further mathematical study. It is however a complex conceptual field. The ICCAMS project, with multiplicative reasoning as one of its two focus themes, has in Phase 1 conducted a broadly representative survey of attainment which suggests that standards in this area have not risen since the 1970s and that relatively few students are achieving competence in the relevant areas of the national strategy Key Stage 3 framework. Student difficulties are illustrated by evidence from group interviews in Phase 2 of the project.

Connecting mathematics in a connected classroom: Teachers emergent practices within a collaborative learning environment

Alison Clark-Wilson

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During 2008-9 seven secondary mathematics teachers from England, Scotland, Netherlands and Sweden began to use a wireless classroom network to link their students' handheld ICT devices. This paper focuses on the teachers' reported uses of the Screen Capture feature, which were coded to reveal patterns in the emerging classroom practices. Analysis of the data revealed: increased opportunities for purposeful classroom discourse; improved

formative assessment practices; and highlighted the need for teachers to choose rich examples on which to build the mathematical tasks.

Roles of Research in the Professional Development of Mathematics Teachers

Els De Geest

The Open University

This paper reports on an empirical study which investigated ways in which research is presented in CPD initiatives and the impact research utilisation in professional development has on teachers. Data consisted of qualitative responses to on-line and electronic questionnaires, field notes of discussions and observations which were validated by the participants. Data was analysed using a process of constant comparison (grounded theory). The analysis offers descriptive categories for ways in which research is used in CPD and for effects research utilisation has on teachers. We conclude that using research is an effective means, although perhaps not the only one, for teachers to becoming aware of different perspectives about teaching and learning, to engage in deep thinking and to gain confidence in their thinking.

Using Realistic Mathematics Education with low to middle attaining pupils in secondary schools

Paul Dickinson, Frank Eade, Steve Gough, Sue Hough

Manchester Metropolitan University Institute of Education

This paper provides an account of two projects involving the trialling of a new approach to teaching in secondary schools in England. The method being trialled is based on Realistic Mathematics Education (RME), originally developed in the Netherlands. The paper focuses on the underpinning of RME, provides an overview of the associated projects, the research methods and initial findings, and explores emerging issues from the projects.

Students' Experience of Mathematics Enrichment

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This paper presents findings on students' experience of mathematics enrichment, arising from a recent and more extensive study designed to inform understanding of different forms and practices of mathematics enrichment in the UK. Four case studies were conducted, each focusing on a distinctive enrichment programme, namely: one set of residential Mathematics Summer Schools, offered by the National Academy for Gifted and Talented Youth; one series of Mathematics Master-classes, run by a Royal Institution Master-class group; an after-school outreach and enrichment programme, targeted at students from a disadvantaged, inner-city area, run in collaboration with NRICH; and the United Kingdom Mathematics Trust's (Junior and Intermediate) Maths Challenge competitions, undertaken in one school. Data were collected through interviews with student participants, informed by observations of enrichment practice. Whilst students reported a range of

enrichment benefits, broadly related to their mathematical, and personal and social, development, support for mathematics learning in school, and exposure to higher education, their experience was more subtly related to the characteristics of the programme in which they had participated, interpreted according to more familiar experiences of learning mathematics in school.

Reasoning on transition from manipulative strategies to general procedures in solving counting problems

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We describe the procedures used by 11- to 12-year-old students for solving basic counting problems in order to analyse the transition from manipulative strategies involving direct counting to the use of the multiplication principle as a general procedure in combinatorial problems. In this transition, the students sometimes spontaneously use tree diagrams and sometimes use numerical thinking strategies. We relate the findings of our research to recent research on the representational formats on the learning of combinatorics, and reflect on the didactic implications of these investigations.

Identifying and Developing Strategies: Beyond Achievement

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To put into praxis the theoretical assumptions that self-regulation skills are teachable (Schunk and Zimmerman, 1998), this paper describes a research on the efficacy of an instructional approach, the Strategic Content Learning approach adopted to promote self-regulated learning in average mathematics performers of grade VIII of Indian schools. These students with poor metacognitive skills, who lacked productive approaches in implementing or adapting learning strategies, were helped to manage their cognitive, volitional and motivational skills. Concomitantly, the students were helped in identifying and developing strategies while solving problems in mathematics. They also developed their personalised strategies that they could transfer across problems and time, thus becoming better self regulators.

Developing early algebraic reasoning through exploration of the commutative principle

Jodie Hunter

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Student transition from arithmetical understandings to algebraic reasoning is recognised as an important but complex process. An essential element of the transition is the opportunity for students to make conjectures, justify, and generalise mathematical ideas concerning number properties. Drawing on findings from a classroom-based study, this paper outlines how the commutative principle provided an appropriate context for young students to

learn to make conjectures and generalisations. Tasks, concrete material and specific pedagogical actions were important factors in students' development of algebraic reasoning.

The Transition to Advanced Mathematical Thinking: Socio-cultural and Cognitive perspectives

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This case study of the first, 'transitional' year of a mathematics programme at a research intensive university aims to deepen understandings of the transition to 'advanced mathematical thinking', or in effect, 'rigour and proof'. The case draws on ethnographic data that includes: interviews with lecturers and students; observations of tutorial/teaching sessions; a video-stimulated recall interview with a lecturer; and documents from relevant A-level and university programmes. We consider insights into transition using Activity Theory (after Leontiev, Cole, Engeström etc.) and draw on selected cognitive perspectives to Advanced Mathematical Thinking (after Fishbein, Tall, Harel, etc.). We conclude that the different activity systems of school and university involve contradictory mathematical practices and hence can result in cognitive conflicts, including those well documented by the cognitivist 'psychology of mathematics education' tradition. Drawing on these perspectives and capturing the voices of students and lecturers may be important to understanding identity, motivation, and student engagement.

Promoting a Cross-curricular Pedagogy of Risk in Mathematics and Science Classrooms

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This paper reports on a research project on the teaching of risk with teachers of mathematics and science in Key Stage 4. Software models of socio-scientific issues have been developed and tested to support teachers towards developing a pedagogy of risk in their teaching. Transcripts from a workshop with teachers are used to illustrate some key findings.

Perceived parental influence on students' mathematical achievement, inclination to mathematics and dispositions to study further mathematics

Irene Kleanthous and Julian Williams

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This paper explores perceived parental influence on students' achievement in mathematics, inclination to mathematics and dispositions to study further mathematics among 563 students in Cyprus. The reliability of the scale designed to measure perceived parental influence was investigated using the

Rasch model. It was found that perceived parental influence had a statistically significant effect on students' inclination to mathematics, but it did not have a statistically significant effect on students' mathematics achievement and dispositions to study further mathematics in Higher Education. The effect of parental influence on students' dispositions towards mathematics is discussed.

The effect of using real world contexts in post-16 mathematics questions

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This paper reports on a study into the effect of real-world contextual framing in sequence questions. Alternative versions of the same questions were presented in explicit, algebraic, word and pattern contexts, and set to a sample of 594 Year 13 students (aged 17-18) in a one-hour test. Facility levels of the questions were then compared. In addition, the paper presents results of a student questionnaire on real-world context which accompanied the test.

Analysing children's calculations: the role of process and object

Carol Murphy

University of Exeter

This paper reviews the role of process and object in young children's calculation strategies. By drawing on the Action, Process, Object, Schema (APOS) framework (Dubinsky and McDonald, 2001) children's calculation strategies are analysed. It is suggested that the opportunity for children to reflect on the actions they perform and also to reason about them is important in developing a coherent framework and hence a deep understanding of the calculation strategies they are using.

Exploring the role of confidence, theory of intelligence and goal orientation in determining a student's persistence on mathematical tasks

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We consider Dweck's (1986) theory on the relationships between students' beliefs concerning the nature of intelligence, their learning goal orientation, their confidence, and their willingness to seek challenges and to persist when faced with difficulties. Dweck's theories have been studied for the past 20 years, for example by Stipek and Gralinski (1996) among many others. In this study the beliefs and behaviour of 182 third level students were investigated. These students had all chosen to pursue an undergraduate course in a numerate subject. It was found that the relationships between theories of intelligence and goal orientations were more complicated than those postulated by Dweck, and in particular seem to differ between the male and female students. We also found that a student's theory of intelligence, goal orientation, and confidence in his mathematical ability influenced his persistence at difficult mathematical tasks. However, once again, differences were found between the male and female groups.

Measuring Mathematics Self Efficacy of students at the beginning of their Higher Education Studies

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We report on the construction and validation of a self-report ‘Mathematics self-efficacy (MSE)’ instrument designed to measure this construct as a learning outcome of students entering their Higher Education (HE) studies. The sample of 1630 students ranged across different programmes with different levels of mathematical demand. The validation of the measure was performed using the Rating Scale Rasch model. Results include measures and fit statistics illustrating the construct validity, and a comparative analysis of sub-groups in the sample (i.e. gender and courses) ensuring validity across different groups. The comparison between the courses indicated the possibility of a two dimensional structure of the construct, which is explored here by performing separated analyses. The paper concludes with methodological implications and substantial considerations regarding the use of this instrument.

Comparison at Two Levels of the Content Treatment of ‘Early Algebra’ in the Intended Curricula in South Africa and England

Nicky Roberts

University of Cambridge

This paper compares the treatment of algebra content in the intended curriculum of the early grades in two countries: England and South Africa. Two levels of analysis are conducted. The first examines the content structure of each curriculum; and the second compares and contrasts the detailed ‘learning objectives’ in England to the ‘assessment standards’ in South Africa. The comparison reveals that a curriculum may include algebra by name, but may not deal with it in much substance (as in South Africa) and, a curriculum may include algebra in some substance, while not mentioning it by name (as in England).

Participation in mathematics post-18: Undergraduates’ stories

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Abstract: This paper reports on some of the social and emotional complexities young people negotiate, consciously or otherwise, when applying to study at university and presents reasons for why good candidates for mathematics degrees may not opt to study mathematics. The research comes from one strand of the UPMAP project which is seeking to understand profiles of participation in mathematics and physics. Data analysed come from narrative-style interviews which were conducted with first-year undergraduates who had A level mathematics and who were studying a range of subjects at university.

Using longitudinal, cross-system and between-subject analysis of the TIMSS study series to calibrate the performance of lower-secondary mathematics education in England

Kenneth Ruthven

University of Cambridge

Evidence from the TIMSS study series is used to calibrate trends in lower-secondary mathematics in England between 1999 and 2007, relative to other educational systems, and in comparison with science. Over this period the proportion of students displaying high achievement in mathematics rose, apparently in response to reforms associated with the national *Strategy*. However, the proportion of students displaying positive attitude to mathematics fell substantially. In both respects, performance in mathematics continued to compare unfavourably with that in science.

Effecting Principled Improvement in STEM Education: Research-based pedagogical development for student engagement and learning in early secondary-school physical science and mathematics

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The *epiSTEMe* project forms part of a national initiative researching means of improving young people's participation and achievement in mathematics and science education. The project involves collaboration between researchers and teachers to devise an intervention, suitable for widespread dissemination, to enhance student engagement and learning in early secondary-school physical science and mathematics. Drawing on the now extensive research base examining US experience of *Standards*-based reform, and parallel research and development efforts in the UK and elsewhere, the project aims to translate promising pedagogical principles into an operational apparatus for viable professional practice.

Enrichment and engagement in mathematics

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In this paper we examine the notions of engagement and enrichment in mathematics. The Royal Institution of Great Britain (Ri) facilitates the Secondary Mathematics Masterclasses project and has been involved in a QCA project to follow teachers' journeys when developing 'rich tasks' for use in school for whole class teaching, both with the aim of 'Engaging mathematics for all learners'. The Masterclasses were evaluated in 2008 by the CEM centre in Durham, and the Ri conducted case studies for the QCA project on how ideas and methods traditionally reserved for the gifted and

talented cohort can be used for a wider range of learners. Drawing on the results of these studies and the research literature, this paper will discuss what is understood by 'enrichment' and 'engagement' in mathematics. In clarifying what we mean by enrichment, we present a structure for enrichment which differentiates between the inputs and the outputs of any enrichment activity, engagement in mathematics being one of the desirable outputs. The findings show that the Ri masterclasses brought about the enrichment outputs we would expect from such activities, with additional outputs for the teachers involved. The Ri's participation in the QCA project has aimed to build on this model in order to maximize such outputs. We explored the impact in teachers' practice when developing rich tasks and the impact on learners. Based on our research, we put forward recommendations for carrying out enrichment activities in mathematics.

Saving Further Mathematics?

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The crisis in science, technology, engineering and mathematics (*the STEM crisis*) has come to the fore in recent years, but problems in mathematics education have persisted for many years. Although there have been many reviews and resulting initiatives none of the attempts to solve the problem has been successful in the long term. This paper reports on research carried out for Mathematics in Education and Industry (MEI) on the impact of the Further Mathematics Network (FMN), which was formed in 2004 to attempt to halt and reverse the large decline in the numbers of students taking further mathematics at A-level. The origin of the FMN in the light of the *STEM* crisis and *Curriculum 2000* is discussed, as is an analysis of the statistics on the subsequent growth in student numbers. This analysis highlighted two types of schools and colleges; those where numbers had grown substantially in recent years, and those where the institution was able to offer further mathematics despite a small take up. Interviews were conducted with the teacher responsible for Key Stage 5 Mathematics in both these types of institution, and reasons sought for why numbers had grown or how courses could be offered "in house" to a small cohort of students. Factors that emerged included the reputation of the department and institution within its locality, the changes made in 2004 to mathematics specifications by the awarding bodies, flexibility in option block and timetabling arrangements, recognition by students that a qualification in further mathematics is a valuable career asset and support for the students and enthusiasm for mathematics from the teaching staff and the Network. These findings are discussed further in the light of the recent consultation on the future of level 3 Mathematics by QCA.

A Student's Symbolic and Hesitant Understanding of Introductory Calculus

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In this paper I discuss a study that looked at one student's understanding of calculus, and used the framework of Tall's theory of Three Worlds of

Mathematics to determine the embodied and symbolic nature of that understanding. Initially, the student's understanding of calculus was explored through a task interview using calculus questions designed to elicit embodied and/or symbolic understanding. Results showed that this student predominantly demonstrated a symbolic understanding, with a very limited embodied understanding on the particular tasks. It was also during this interview that the student exhibited the phenomenon of searching for reassurance as to whether he was answering the task and interview questions correctly. This paper discusses this search for reassurance, speculates on potential causes, and argues that there may be a relationship between this search for reassurance and the student's symbolic understanding of calculus.

Conceptualising the mediation of mathematics in classrooms as textured narratives

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This paper builds on a framework that conceptualises mathematics teachers as narrators developing narratives that interweave two important strands that we identify as being focused on the mathematical and social. It is these narratives that we consider to mediate the mathematics for students in classrooms that in turn we consider as activity systems and analyse using Cultural Historical Activity Theory. We draw on case study data collected in the ethnographic tradition in colleges as part of a project funded as part of the ESRC Teaching Learning Research Programme (TLRP) to consider how implicit in such narratives are socially emergent and shared understandings of what constitutes mathematics itself and what it might mean to be a mathematician in different settings. Giving a texture to teachers' narratives, therefore, we identify factors relating to shared epistemologies and didactical contracts (Brousseau, 1997) that we find crucially important in defining what it means to study mathematics as a discipline.

Secondary mathematics departments making autonomous change

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In the *Changes in Mathematics Teaching Project* three mathematics departments made autonomous changes to their practice in KS3. We chronicled aspects of their practice, tracked a focus sample of students, and obtained KS3 results for the cohort. This paper reports characteristics of the department activity and identifies common features and difficulties which may be associated with the effects of the changes.

Prospective elementary teachers' beliefs about problem solving: A comparison of Cypriot and English undergraduates at the commencement of their courses

Constantinos Xenofontos and Paul Andrews

University of Cambridge

The research reported in this paper draws on semi-structured interviews conducted with first-year undergraduate teacher education students, in the first weeks of their course at one university in Cyprus and one in England. The interviews, focused on students' conceptions of mathematical problems and problem solving yielded substantial, culturally-located variation in students' responses highlighting continuing inconsistencies in the operationalisation of this key concept around the world. Some implications for teacher education and further research in the problem solving field are discussed.

PART 2

Non-refereed research reports which were written following presentations at the seventh BCME conference.

The emergence of rhythmic patterns as a way of embodied mathematical knowing

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This qualitative study is part of a 2-year longitudinal research focused on theorizing the role of the body in elementary students' mathematical learning and understanding. More specifically, we are interested in exploring how children's transactions with geometric objects give rise to ways of embodied knowing. Drawing on an exemplary episode in which a group of 3rd-graders were classifying three-dimensional objects, our purpose is to illustrate a way of embodiment not addressed in previous investigations, namely "embodied rhythm". A rhythmic choreography emerged during the transaction between one of the students with a cream carton. The rhythm of that choreography was especially clear in the beats the student performed on the object's faces. Other two embodied dimensions produced the same rhythmic pattern: object orientation and body position. Based on a detailed micro-analysis, embodied rhythm is conceptualized as a way of mathematical knowing, as well as a means of objectification of mathematical understanding.

Why do students not avail of mathematics support? A case study of first year students at the National University of Ireland Maynooth.

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Previous work concerning the evaluation of mathematics support services at NUI Maynooth showed that students who made use of the help available were more likely to succeed in their examinations than those who did not. It was also noticed that a significant number of at-risk students did not attend the Mathematics Support Centre. In an attempt to ascertain the reasons for this, students who were repeating mathematics modules were interviewed about their use of mathematics support. The results show that fear plays a major role in non-engagement.

Visualisation of cosets and its impact on student engagement with Group Theory

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Group Theory is considered by students as one of the most taxing topics of their university studies. In this study, I scrutinize the role of visualisation in the student engagement with Group Theory, focusing, in particular, on the notion of coset which its introduction, according to the data, is the first major milestone students need to face and overcome. The data consists of: observation notes and audio-recordings of lectures and group seminars of a Year 2 course; student and lecturer interviews; and, coursework and exam papers. Moreover, I offer some excerpts from the collected data which demonstrate the link between the ability to visualise the concept under study and the development of student engagement.

Using ICT to develop abstraction

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As teachers we are constantly encouraged to make more use of ICT in the classroom. In tandem with this there is a perception that many students are embarking on A-level courses with little grasp of abstraction and consequently immediately struggle with the algebra. This paper attempts to use a model of conceptual development and, with the insights it provides, identify ways in which ICT can aid students' conceptual abstraction.

The perceptions of students in Initial Teacher Education regarding Logo and its use in primary schools

Susan McLarty

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Anecdotal evidence in 2009 suggested that Initial Teacher Education students in Bachelor of Education (BEd) mathematics classes appeared to have mostly negative perceptions of Logo, which constituted part of the second year course and was a recurrent theme in workshops. The aim of this research was to find out whether this was actually so and if it was, what students disliked about Logo and why they questioned its use in primary school mathematics teaching. The research also aimed to improve future course design. Student and staff views were collected through questionnaires and interview. Return rates for student questionnaires and numbers participating in discussion were small, but confirmed the negative perceptions of Logo in most regards. However, students indicated that several suggested changes to the course might be beneficial and these were implemented in the 2010 course. A similar questionnaire surveyed the views of this cohort of students at the end of the course, and found that perceptions of Logo were broadly similar to those of the 2009 cohort.

Instructional aids, school variables and pupil's Mathematics achievement in primary schools in Cross River State, Nigeria

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The aim of the study was to determine the effects of the use of instructional aids, and school variables on pupils' Mathematics achievement in both public and private schools in Cross River State, Nigeria. The study adopts the quasi – experimental research design involving pretest – posttest with the use of instructional aids as the treatment for the experimental group. School variables (school location and school type) were the main variables, while gender was the moderator variable. A random sample of 600 pupils was selected using the multi - stage sampling technique for the study. The experimental group was subjected to the treatment, which was teaching with instructional aids. The administration of the treatment lasted for six weeks. A 20–item multiple-choice Mathematics Achievement Test (MAT), designed by the researchers, with a split–half reliability index of 0.67 was the instrument used to gather data. The MAT was used as pretest and posttest for both the experimental and the control groups. Data collected from the study were subjected to the Analysis of Covariance (ANCOVA) with the pretest scores as the covariate. The results of the analysis showed that pupils' Mathematics achievement was significantly dependent on the treatment, school type and school location but not on their gender. Also all the interactions of the treatment, gender, school type, and school location were statistically significant in explaining pupils' Mathematics achievement. In fact, in the urban areas, pupils in the experimental group in private schools achieved significantly higher than their

counterparts in the public schools. However, in the rural areas, the difference between the mean Mathematics achievement of the pupils in private and public schools was not statistically significant.

The Rise and Fall of Certainty

Scott Waygood

Westminster City School

Most people take it for granted that mathematical knowledge is certain. People believe that we can be absolutely certain that $2 + 2 = 4$ or that the theorem of Pythagoras holds true on flat surfaces. However, within the philosophy of mathematics, the thesis of certainty has reached crisis point twice during the past 200 years. By examining the events surrounding these crises, I shall demonstrate the influence that philosophical accounts of the nature of mathematical knowledge have on curriculum development and pedagogy. Finally, I will examine the pedagogical implications of the leading contemporary account of mathematical epistemology.