LANCASTER UNIVERSITY

MAESTRO

MATHSALIVE EVALUATION STUDY
AN EVALUATION OF IMPACTS ON LEARNING

FINAL YEAR SUMMARY REPORT

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WHAT IS MAESTRO?

The Maestro Project was set up to explore how the introduction of RM MathsAlive into a number of mathematics classrooms and departments might impact on mathematics learning and teaching over a three-year period. MathsAlive is a range of information and communication technology (ICT) resources that provides a complete curriculum for Key Stage 3 mathematics learning, including specific resources created to meet each of the objectives in the Secondary National Strategy framework for teaching mathematics. It is supported by a management system called the Kaleidos Virtual Teaching and Learning Environment (VTLE). The Maestro Project was initiated in 2003, with the participation of 27 schools, and followed the progress of pupils from Year 7 to Year 9.

The key aims of the project were to:

1. Evaluate the effect of MathsAlive on attainment in mathematics in Key Stage 3.
2. Evaluate the impact of MathsAlive on mathematical understanding.
3. Determine the most effective teaching methods with ICT resources and how to support these.
4. Understand the key drivers involved when positive change was recognised.

The Maestro Project was evaluated across the three-year period, initially by Debbie Yates from University College Chichester. This summary integrates findings from that initial evaluation, but focuses on the main findings of the evaluation conducted in the final year by the author, Don Passey, from Lancaster University. The evaluation of the Maestro project focused centrally on learning – looking at what drives learning, what aids retention, and what impacts actual attainment. This paper summarises the findings that show how MathsAlive resources impacted on teaching and learning. (It should be noted that in lessons observed, the majority of activities used MathsAlive resources. These resources were augmented in some lessons by teacher-created ICT activities and some from other sources.) This summary covers findings that explore:

- The impact on learners
- The impact on teachers
- The impact on learning
- Implications for school management
- The impact on attainment

This summary report will be extended to incorporate study findings from the Fischer Family Trust, which seeks to quantify impacts on attainment.

THE IMPACT ON LEARNERS

The evaluation asked a range of pupils at the end of Year 9 to complete a questionnaire (426 pupils responded from 19 schools). These results alone were compelling in terms of indicating impact:

- 63% of pupils said that their enjoyment of mathematics had increased since the beginning of Year 7;
- 81% of pupils believed that they could learn new things in mathematics more easily than at the start of Year 7;
- 87% of pupils enjoyed using the interactive whiteboard in mathematics lessons;
- 71% of pupils thought that it was easier to remember things when they used the interactive whiteboard; and
- 69% believed that playing mathematical games helped them to remember things (although slightly fewer indicated that they enjoyed playing mathematical games).

The pupil questionnaire responses suggested that the use of the resources was having a positive impact in many cases on pupil enjoyment, motivation towards learning, and perceptions about learning mathematics.

Interviews were conducted with 57 pupils across 19 Maestro Project schools, and their responses offered a greater insight into the reasons behind positive questionnaire responses. From these interviews with pupils, five key elements commonly felt by pupils to be underpinning this impact were identified.

1. Enhancing visual clarity

The fact that a square is shown accurately, rather than as a sketch, for example, is potentially significant. Most people remember a square as a clear four-sided object with equal sides, subtended at 90 degrees at each corner. This form of memorised image allows the 'rules of being a square' to be related through the memorised image. If a square is depicted as a sketch, then the rules of being a square need to be remembered separately and applied to this object. Remembering the object as a clear square means that the rules can be 'seen' more readily. The extent of impact of visual clarity is not quantified by this study, but many pupils referred to similar aspects across a range of mathematical topics as being important in terms of their learning.

2. Clarifying a process

A major role of discussion and questioning is the clarification of mathematical process. The discussion of strategies, and approaches to problems, means that pupils have the chance to clarify processes involved in tackling problems. Pupils not only have the chance to consider how other pupils are tackling process, but also have the chance to verbalise process. Verbalisation can help to clarify and to reinforce understanding; it is arguable that verbalisation is as important as, if not more important than, undertaking a series of examples in silence, written into exercise books. The importance of clarification of process is an aspect referred to by many pupils.

3. Developing conceptual understanding
Pupils referred often to the roles of visual imagery, animations and videos in helping them to understand and to develop concepts and conceptual understanding. Moving imagery was clearly a key means for pupils to 'see what is meant', rather than their trying to 'imagine what is meant' when it was just described by teachers. Imagining what is meant can mean that pupils have to imagine the steps in a process, or the flow of a phenomenon. Use of visual and moving imagery means that pupils can see these aspects, and their understanding can be modelled, rather than assumed.

4. Encouraging participative learning
Many pupils referred to different aspects of participative learning, whether this was in terms of increased opportunities for group discussion, or all individuals from across a class taking part in games. Participative learning was reported to be important by two groups of pupils who were interviewed, but in different and significant ways:

- Those who had difficulty in participating because of low engagement levels were drawn into activities that included games.
- Those who felt uncomfortable when some pupils were not engaged in lesson activities felt comfortable and more emotionally accepting of the situation when participation was wide.
  It was not clear from the study how many pupils might fall into these categories, but pupils referred specifically to the importance of enhanced participation on their learning.

5. Increasing pace and variety
Many pupils referred to increased pace and increased variety as being important factors in enhancing their learning. Pace enables a better flow to be maintained, both for those who are distracted by breaks in flow, and for those whose understanding is interrupted by breaks in flow. Introducing a variety of resources on an interactive whiteboard means that different activities can be introduced more seamlessly, without long periods of waiting between one activity ending and the next one starting. Pupils reported that they noticed these advantages, and pupils felt they contributed to learning in important ways.

THE IMPACT ON TEACHERS

Interviews were conducted with key teachers in 19 Maestro schools, to gain ideas about how embedding ICT into their subject had affected their teaching.

Many teachers reported that their use of MathsAlive had had an impact on their teaching. Some reported that the focus of the lesson had changed, moving the focus away from them as the teacher towards more of a focus on the resources they were using. Some teachers felt the ICT-based resources enabled a more collaborative environment to emerge, where they were working with pupils to construct problems and devise methods to solve them. These forms of focus were moving teachers away, as one teacher said, from 'what to teach' to thinking about 'how to teach'. Some teachers reported that MathsAlive extended their teaching styles to incorporate more high-level discussion, group work and linking different areas of the curriculum within real-life contexts.

From in-depth lesson observations in Maestro schools, it is clear that teachers can have a dramatic effect upon pupil learning. The key elements to support learning that were identified by pupils require teachers not only to focus on selecting and using appropriate resources, but also to consider and use the best ways of integrating the resources. Three key elements concerned with teacher approaches were identified in this respect:

- Aspects of metacognition – how pupils can become aware of their own learning and approaches they can take to learning.
- Discussion - how pupils can become actively involved in dialogue about mathematical strategies rather than providing answers to closed questions or merely 'right' answers.
- Transfer of knowledge - how pupils can use existing knowledge in lessons and consider how to use the knowledge gained in a lesson in other circumstances.

THE IMPACT ON LEARNING

When analysing the results of the evaluation study, a learning framework, found on page 5, was used to identify key elements contributing to and driving learning in these classrooms. Learning elements were reviewed in detail, but the broad categories covered were:

- Megacognition
- Cognition
- Metacognition
- Motivation
- Social Interactions
- Societal Implications

Using the learning framework selected, uses and outcomes of the MathsAlive resources to support mathematics teaching and learning were reviewed. The diagram on page 5 highlights where MathsAlive was found to have an impact. Evidence for this analysis came from the widest possible range of sources, from lesson observations, interviews with teachers and pupils, and pupil questionnaires:

1. Megacognition
Megacognitive aspects include knowing about the 'big picture', being able to work in Zones of Proximal Development, and the transfer of learning. MathsAlive resources were not used to provide a 'big picture' for pupils. In terms of working within Zones of Proximal Development, MathsAlive allowed many teachers to select resources and activities appropriate to the mathematical skills and understanding of pupils in their classes, or to adapt resources to accommodate the needs of gifted and talented pupils or those with specific educational needs. While some teachers were concerned with the transfer of previous learning into lessons, only a minority focused on the transfer of learning from a lesson to other situations.

2. Cognition

Cognitive processes can be grouped into three separate areas; internalisation – how information is acquired; internal cognitive processing – how the brain analyses and stores this information; and externalisation – how knowledge is shared with others. MathsAlive supported some important specific elements within these groups:

a. Multi-sensory learning

Internalisation of information requires both attention on the topic, and a stimulus of suitable sensory routes through which pupils can acquire and receive information. When an interactive whiteboard is used, attention is maintained, a number of sensory routes are stimulated, and acquisition and reception of ideas or knowledge are encouraged. Attention is maintained because of the size of images and text, the clarity and detail, as well as colour and movement. With this form of resource, handwriting is much less effective, but handwritten annotations on electronic text or prepared resources can highlight aspects well for pupils. The use of timers to count down, of sound to indicate when things have been achieved, of covered items that can be uncovered, and touching the interactive whiteboard using pens or fingers by pupils themselves to show how they have tackled problems, all add to the richness and diversity of the multi-sensory dimension.

b. Knowledge acquisition

Knowledge acquisition is an important initial element that can be a prerequisite to the development of aspects of higher order knowledge handling. MathsAlive resources support knowledge handling through clarity and visibility. Pupils recognise both the value of having clear images, and the importance of having examples to see at the time they are asked to think about a mathematical issue. Pupils can see images clearly when working with aspects of shape and space, or when thinking about what happens to graphs when parameters are changed (as they do not have to wait for it to be redrawn).

c. Concept formation

Concepts are ideas that are generated from a range of experiences, or ideas that can generalise findings or results. Clarity, visibility and visualisation all help with concept formation. Understanding what happens to the shape of a graph of the equation $y = mx + 10$, when m is 0, 1, 2 or any other number, can be visualised by a pupil easily if the graph is very quickly generated and can be compared to previous graphs. Simulations, animations and the comparison of results all support the formation of concepts.

d. Higher order thinking skills

Higher order thinking skills are often associated with processes such as analysis, synthesis, and evaluation. In some lessons observed, teachers used interactive whiteboards in novel ways to explore an analysis of data. The interactive whiteboard allowed batches of data to be built up, with pupils directly involved in 'handling' the data, and seeing what happened when greater quantities were built up (on the mean, mode and median). Using MathsAlive, teachers engaged pupils in open discussion, and encouraged them to draw ideas from their existing knowledge, as well as asking them to indicate how far they accepted their peers' ideas and strategies for addressing problems.

e. Knowledge retention and recall

Many teachers believed that pupils were able to make mathematical connections between concepts more effectively because visual imagery improved knowledge retention. Some teachers reported that thinking more about the visual impact of what was being taught had had an impact on their teaching. Some pupils certainly reported that visual elements attracted them and offered more variety. Clarity, visibility, and visualisation leading to effective modelling and holding of rules and ideas appeared to have had impact on knowledge retention and recall.

f. Externalisation

Teachers moved away from using writing as the only form or major form of externalisation. Some teachers reported that moving from pupil writing to pupil discussing had been an outcome that had impacted on their teaching. The need for pupils to discuss and to explain things for themselves is clearly an important form of externalisation that should be easily as prominent as the writing of answers in exercise books. In some lessons observed, pupils needed to come to the interactive whiteboard to show how they had undertaken a task, and to present this to the rest of the class. Discussion and presentation were more prominently used by a number of teachers to offer effective ways to support externalisation of knowledge and understanding.

3. Metacognition

Metacognition involves the detection and correcting of errors, the selection of suitable strategies, and the pacing of work. MathsAlive resources can be used to support metacognitive learning strategies. This includes giving pupils the opportunity to find out if they were right or wrong, being able to address misconceptions and identifying how to do better next time. Teachers in some lessons observed were able to annotate screens, and to point out specific detail to help to focus the attention of pupils. Although screens needed to be generated electronically for clarity, specific attention was easily drawn to points by the teacher drawing or writing by hand on the screens. The use of technology enabled pupils' work to be shared more easily, allowed them to show how they produced an answer and gave the opportunity to create and test general rules. Teachers believed the resources allowed lessons to run and flow more easily. Lesson observations showed that there were few places where the flow of the lesson was interrupted. Teachers did not need to turn their backs to the class, and could move seamlessly on to other material or back to recap on points already covered. Effective use of MathsAlive resources and the interactive whiteboard ensured pace throughout the lesson.

4. Motivational Aspects

Forms of positive motivation are enhanced when MathsAlive resources are used effectively. Some pupils explained that the work was broken down into steps rather than being 'in big chunks in a text book'. When presented with 'loads of writing' this was found to be daunting, and pupils then felt that they could not do the work. Some teachers believed that pupils were motivated because they saw mathematical ideas presented through a recognised resource as being akin to a 'universal truth'. Motivation is enhanced when you

MEGACOGNITIVE

Knowing about the big picture
Working in a Zone of Proximal Development
The transfer of learning

COGNITIVE

INTERNALISATION

Attention			Acquisition or reception
	Sensory stimulus	Visual Auditory Kinaesthetic Emotional Social Textual Musical Interpersonal Intrapersonal	

INTERNAL COGNITIVE PROCESSING

Subject knowledge	Searching Generating or developing ideas Hypothesising Imagining Gaining skills Gaining understanding
ICT knowledge	Skills Understanding

Knowledge handling	Acquisition Comprehension Application Analysis Synthesis Evaluation	**Thinking**	Creativity Enquiring Questioning Conceptualising Comparing Reasoning Interpreting		Concept formation Reconstruction of ideas

Retention	Visual Auditory Kinaesthetic Emotional Social Textual Musical Interpersonal Intrapersonal	Rehersal Short-term memory	Long-term memory	**Recall**	Visual Auditory Kinaesthetic Emotional Social Textual Musical Interpersonal Intrapersonal

EXTERNALISATION

Motor stimulus	Writing Reporting Speaking Presenting Drawing Completing Moving

METACOGNITIVE

Monitoring task performance	Keeping place, sequence Detecting and correcting errors Pacing of work
Selecting and understanding appropriate strategy	Focusing attention on what is needed Relating what is known to material to be learned Testing the correctness of a strategy

MOTIVATIONAL

Learning goal
Academic efficacy
Identified regulation
Intrinsic motivation
Performance approach goal
Performance avoidance goal
External regulation
Amotivation

SOCIAL

Learner interaction	Instruction Explanation and illustration Direction Demonstration Discussion Scaffolding Questioning Speculation Consolidation Summarising Initiating and guiding exploration Evaluation pupils' responses

SOCIETAL

Caring thinking	Appreciative Active Normative Effective Empathetic
Contextual thinking	Education Citizenship Work Recreation

know how you can tackle problems. Many pupils felt that they could tackle mathematics more readily as a result of using MathsAlive and similar resources. Some pupils certainly showed that their expectations could be raised when using ICT resources. One pupil pointed out to another who was trying to create an angle of 90° using Geometer's Sketchpad that making an angle of 90.9° was 'poor'. The pace of lessons was also felt by pupils to help their motivation; they found that lessons were conducted at a quicker pace, without the need for the teacher to write so much, but having resources prepared and loaded in advance.

5. Social Interactions

A range of forms of social interaction are supported when MathsAlive resources are used. These forms of interaction are potentially positive for both the learner and the teacher. Some teachers believed MathsAlive and similar resources allowed lines of questioning to be explored more. Pupils in some lessons were given opportunities to discuss questions or concepts in pairs or small groups. Teachers believed MathsAlive supported them in evaluating pupil responses. A teacher observed in one lesson asked pupils for their solutions first, and then only after exploring all pupil solutions was the teacher's own solution offered. Wide participation in lessons was clearly an important outcome of uses of some MathsAlive resources for some pupils, particularly when games were used. Students who were generally less well engaged and those who were sensitive to the behaviour of those around them both described the benefits of increased participation using MathsAlive resources. This effect is important in terms of supporting positive social classroom dynamics that can enable more effective and wider learning to result.

6. Societal Implications

Many pupils want to understand how mathematics will help them in the future, and how it will relate to their future interests and needs. Certain societal aspects can be introduced that will help pupils in this respect. Some pupils valued games and other activities, not just because they enjoyed using these resources, but also because they enabled participation of all pupils in the class. A range of pupils recognised the value of activities that were seen to 'care for others'. Teachers reported that having more application to real life situations had had an impact on their teaching. Teachers believed MathsAlive resources, such as video openers, could provide practical contexts for mathematics, which was important for pupils if they were to see value in mathematics that was wider and longer term than just subject interest.

THE IMPACT ON SCHOOL MANAGEMENT

Embedding uses of ICT-based resources into teaching and learning is likely to be supported most effectively when systemic change approaches are adopted – at teacher, department and school levels. Evidence from teachers and pupils across the Maestro Project would suggest that adopting MathsAlive and similar resources into teaching and learning of mathematics is worthwhile, and that considering how to bring about an effective integration of these resources is a valuable management task.

From interviews with senior managers in Maestro Project schools, the evaluation has identified successful approaches to change management when embedding ICT effectively into the teaching and learning of mathematics. There are approaches that need to be considered, to support teachers, through departments, and through the whole school, when taking this form of change on board.

1. Managing change at the teacher level

Teachers will need support as they develop new skills when integrating ICT resources into lessons: They will:

- Experience an initial increase in workload, familiarising themselves with the new resources and management system. Standard training and support are critical at this time.
- Need support to maximise the benefits and potential of a multi-part lesson.
- Save time by using prepared resources as a starting point, giving them more opportunity to modify these resources to meet the individual needs of their pupils.
- Use more time planning how pupils can learn rather than just what to teach.
- Reduce their workload in the long term, as plans can be shared between teachers and easily improved from one year to the next. This gives them the opportunity to continuously enhance the learning opportunities they create for their pupils. Opportunities to discuss and develop practice are invaluable at this point.

2. Managing change at a department level

Evidence from the Maestro Project suggests that three key features, which support the management of change at a department level, are:

- The allocation of time for training. Teachers need operational training and support initially, followed by further training in the uses of more specific resources and management facility features.
- Time to view activities. During the first year of use particularly, there is a need for teachers to review resources, to identify how they will use them within lessons. If time can be devoted to this review, within department time, then it is of wide potential benefit to all teachers.
- Sharing good practice. Opportunities to share practice are important. Some departments put departmental meeting time aside for these purposes. Other departments discuss practice through monitoring and observation practices.

3. Managing change at a school level

In terms of school level support for change, the evaluation identified a number of key factors:

- Senior management endorsement and support. Effective schools developed methods of tackling access, timetabling and resource needs where necessary. They set up appropriate line management structures and empowered individual members of staff to explore new ideas. They offered time and training to teachers at all stages of implementation, giving them the incentive to develop their ideas further.
- Access to hardware. A number of schools ensured that all classrooms where mathematics was taught had interactive whiteboards.

- Effective in-school ICT or technical support. Schools supported heads of department and teachers through effective in-school technical support. Schools put provision in place to address technical issues that arose efficiently and quickly, ensuring teachers remained focused on curriculum needs.
- Use of INSET or training support days. Schools supported heads of department and teachers who wanted to attend outside school INSET and updating sessions, as well as supporting visits from external personnel to work with specific teachers or all teachers within the department. They ensured new staff were kept up-to-speed and provided support for staff at an individual, department and 'beginner' level.
- Giving departments what they need to develop an effective team. Effective schools enabled teachers to see what other teachers were doing, and the benefits arising from their actions. They created staff realism whilst promoting team building within departments. They provided time for departments to meet together, and made pedagogy a team ethos. They ensured departmental meetings had an appropriate focus on the integration of ICT-based resources and made it a priority to bring the enjoyment of mathematics into the classroom.
- Extending lessons learnt beyond initial departments. Schools who had a vision to embed ICT into all areas of the curriculum generated wider commitment from staff and more involvement from other departments. They engaged more heads of department and had a clear action plan to use the experience of the lead mathematics department to extend their expertise across the school.

THE IMPACT ON ATTAINMENT

A comprehensive study is being carried out by the Fischer Family Trust to quantify the improvements in attainment made by pupils within the Maestro Project. The findings of this study will be combined with the results of this evaluation summary to explore possible relationships between levels and types of use of MathsAlive and additional gains in attainment made by pupils.

As part of the evaluation reported in this summary, a number of teachers stated that they believed that the use of MathsAlive was having a positive impact at a subject attainment level. During a number of the later evaluation visits, when provisional SATs results were known, five schools reported improved Key Stage 3 mathematics results. The reason for this improvement was put down, at least in part, to the use of MathsAlive. During interviews with pupils, without prompting, some pupils stated that MathsAlive helped them to answer SATs questions.

From the number of schools reporting a positive impact in attainment when their provisional results were known, it seems unlikely that the number of schools having improved results would have occurred coincidentally. A more detailed quantitative analysis of the SATs results being carried out by the Fischer Family Trust will allow this possibility to be explored further.

If you would like to be sent further results from the Maestro Project, including a summary report integrating the quantitative analysis carried out by the Fischer Family Trust, please visit **www.rm.com/maestro** and complete the request form.

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