MOBILE TECHNOLOGY IN THE SCIENCES

THE MOTIS PROJECT

By Andrew Tideswell

Milestone and Case study into hand-held technology being used at Wainuiomata High School, Paraparaumu College, Naenae College and Wellington Girls' East College.

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MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga

Mobile Technology in the Sciences (MOTIS)

MOTIS is a three year project operating in four Wellington high schools: Wainuiomata High School, Naenae College, Paraparaumu College, and Wellington East Girls' College. The project is developing the use of hand-held technologies (newer graphics calculators, data loggers, portable wireless networking systems) in cluster schools to increase the effectiveness of curriculum delivery in the Mathematics and Science. MOTIS also aims to improve the participation and retention of students in senior science and maths, and raise the achievement outcomes in these curriculum areas.

Former Minister of Education, the Hon Trevor Mallard, with WHS students at the launch of MOTIS.

Launched by the former Minister of Education, the Hon Trevor Mallard in February 2005, the MOTIS project operates in the mathematics departments of each the participating schools, and has expanded into the science departments with the introduction of data logging during 2005.

Origins

The project director, Andrew Tideswell, had some years teaching experience with the use of computer technology, and a previous generation of graphics calculators (the most widespread generation still being introduced to most New Zealand schools.) The technology available then was used to address pedagogical issues in teaching mathematics, and to help students deal with the demands of the NCEA assessment regime. However, there were frustrations with cost and availability of computer based systems, the relative lack of reach of graphic calculators, and a lack of maturity of the technology available as tools for teaching. There was also frustration at the lack of a well developed, affordable and accessible training and pedagogical support structure for the technologies.

In 2003/04, the emergence of technology that was specifically developed to support the teaching of mathematics and sciences, and which was robust, affordable, portable, with mature on line and face to face training and support systems, made successful integrated use a possibility.

Hand held technology.

Andrew became aware of the cross-curricular possibilities of the technology, including its application to the sciences, and its suitability for supporting pedagogical change. These factors would facilitate the broadening of mathematics teaching methods and content.

A series of one day workshops on using the technology were offered at Wainuiomata High School in early 2004. Following the workshops, Texas Instruments, well known for their development of leading edge technology such as the first integrated circuit, expressed interest in supporting a project as business partners. Texas Instruments were also willing to support research in the mobile technology field. Within the Wellington region, there were schools using earlier generations of graphic calculators with staff keen to move beyond the conventional.

Rob Mill and Janice Campbell, principals of Wainuiomata High School (WHS) and Wellington East Girls' College (WEGC) respectively, had both supported the introduction of the technology for some years. Staff from Paraparaumu College and Naenae College also supported the technology's introduction.

Mission

The facilitators met in 2004, and decided to focus on examining and changing their own teaching practice and belief system (pedagogy), and also to extend the cognitive reach of their students.

Appointed as the project's academic mentor was Dr Stephen Arnold, a Visiting Fellow at the Australian Catholic University – Canberra Campus (ACU). Dr Arnold was a senior lecturer in mathematics education and the former Head of School in Education. He is a well respected researcher in the field of technology and mathematics.

The facilitators met with Dr Arnold and decided to focus on three areas of pedagogy:

1. Connectedness – the connections between what is taught in the mathematics or science classroom, and the greater world.
2. Engagement – the quality and degree of student engagement in learning tasks and performances.
3. Deep understanding - a measure of the intellectual quality of the tasks in which students engage.

Participants and Resources

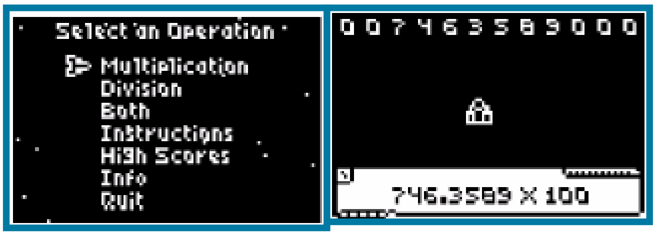
Texas Instruments (TI)

Texas Instruments designs, develops and supplies classroom technology, including hand-held technology. TI, through its New Zealand Education Manager, Yvonne Blanch, donated resources including class sets of flash-enabled graphic calculators, data logging equipment and probes.

TI also provided quality professional development, which included hosting the four facilitators at the MAV conference in Melbourne in 2004.

TI and Yvonne are a critical part of the MOTIS project.

Technology Resources



The Decimal Defender app. is an instructional game that supports operations on decimals.

For 2005, the MOTIS schools selected flash-enabled graphic calculators as the main tool. They have upgradeable operating systems, unlike other devices which can quickly become obsolete. The inclusion of flash-memory means the calculators can be equipped with a range of applications (app.s), such as: language localisers, interactive educational games, a help programme, geography and science app.s, study cards, a personal organiser, spreadsheets, and word processor. If required, a full sized keyboard can be connected to the device.

The schools also chose Calculator Based Laboratories (CBLs). By plugging in any one of dozens of available probes, students turned their calculators into robust, portable laboratories, capable of measuring acidity, dissolved oxygen, speed and motion, light intensity, heart rate, blood pressure, forces on an object, their own force, and sound waves.

During 2005, TI also donated to WHS the latest portable wireless system, Navigator®. As one of only six Australasian schools piloting Navigator®, students used this to contribute data to group work, while the teacher used it to check student understanding.

The MOTIS schools also selected software that enabled students to import digital images of experiments and lessons into a file. This year, 2005, has been a process of familiarisation - it is expected MOTIS science teachers will use this software in 2006.

Digital Opportunities Projects

The project has been made possible by the Ministry of Education's Digital Opportunities Projects. DigiOps has enabled the facilitators to be released for part of their teaching timetable to develop and trial activities and resources, and provide support and training to other school staff. DigiOps has also provided advice guidance, and facilitated communication with schools and interested groups external to the project.

Research Mentor – Dr Stephen Arnold (Australian Catholic University)

Dr Stephen Arnold.

Dr Arnold has a well established international reputation in the fields of CAS and other Mathematics technology. His contributions have included presenting and demonstrating models of teaching practice, such as the Quality Pedagogy Model, from which MOTIS selected its goals, and evaluative outputs. Dr Arnold also provided research tools such as the classroom environment surveys which he assisted in adapting to meet the project's needs. He has modelled the practices MOTIS seeks, and has on occasion delivered lessons in MOTIS classrooms.

Dr Arnold is a practicing mentor, rather than a non-practicing "expert." This has been important to the project. Much can be lost if teachers are asked to participate in a technology project where the "lead tutor" may once have been a practicing teacher but has since become a pure theorist, possibly "losing touch" with the nuances of everyday teaching!

The Cluster Schools

The MOTIS schools have offered release time for training, conference attendance, workshops, and provision of work spaces for the facilitators. Principals in all four schools have been supportive, with one principal using the technology in his own mathematics class.

The schools are:

- Wainuiomata High School: a decile four state-funded, multi-cultural, co-educational school of 939 students, located in the Hutt Valley, 30 kilometres north of Wellington;
- Wellington East Girls' College: a decile seven state-funded, multi-cultural, girls' school of 929 students, located three kilometres from central Wellington.
- Naenae College: a decile two state-funded, co-educational school with 901 students, located 30 kilometres north of Wellington in the Hutt Valley.
- Paraparaumu College: a decile nine state-funded, co-educational, predominantly European school of 1288 students, located on the Kapiti Coast, 60 kilometres north of Wellington.

Current MOTIS staff:

- Andrew Tideswell - Project Director, Wainuiomata High School
- Roseeta Prasad - Science Facilitator, Wainuiomata High School
- Paula Spence – Facilitator, Paraparaumu College
- Barbara Aires – Facilitator, Wellington East Girl's College
- Ian Husband and Jo Cullen - Co-Facilitators, Naenae College

CORE Education:

Core Education (formerly UltraLab South), offer guidance and support with research. MOTIS investigates and reports on the effects of the project on the classroom environment, student attitude, and the practices and beliefs of participating teachers. Michael Winter from CORE assists with and reports on the overall operation of the project.

Mindspring:

Mindspring is a New Zealand site for teaching and learning resources for teachers. Judy Lymbery from WHS offered training for the MOTIS facilitators on behalf of Mindspring. Established in 2001, Mindspring is a collaborative venture involving Microsoft and Unisys Ltds, and is also a DigiOps project. www.mindspring.school.nz .

Project Developments to Date:

Support given to New Zealand teachers through MOTIS resource production:

Resources were quickly developed to support teachers new to using HHT in NCEA 1 and 2 Level Mathematics, and were published online by Texas Instruments at: connecting-t3.com . The resources can be handed directly to students, and used as a guide for each Achievement Standard.

MOTIS outputs to support teacher change:

Naenae College biology trip.

For teachers of junior mathematics and science classes, rich tasks have been developed, trialled and published online, supporting engagement, deep understanding, and connectedness. MOTIS will continue to develop NCEA teacher guides in 2006, although they are largely "training wheels" for novices. As the project develops and matures, MOTIS will move more into the development of rich tasks that support **quality pedagogy.**

In 2005, MOTIS presented at the ULEARN conference in Auckland, and at the New Zealand Mathematics teachers' NZAMT conference in Christchurch. The MOTIS team also held workshops at schools outside the group.

Paula Spence from Paraparaumu College was one of five Australasian recipients awarded a TI scholarship for her development of a statistics-based task. The scholarship gives Paula an all expenses paid trip to the world-leading TI T-Cubed technology conference in Denver, Colorado in February 2006.

Obstacles and overcoming them:

As with any new project, there have been frustrations and obstacles. These include a lack of knowledge of the new flash-enabled devices, and confusion with obsolete technologies already in use (such as the conventional graphics calculator). Consequently, the new technology has not been readily incorporated into junior or senior teaching programmes.

Facilitators have trodden a delicate path, and the best approach has been for the facilitator to start using the technology in class. Word of mouth has piqued student and teacher interest to enquire further about the technology. Where teachers at a school managed to persuade staff to adopt the technology as a group, the school was able to make more rapid progress during the year.

At the other end of the scale, some participant teachers failed to adopt the technology completely. For example, some viewed using technology during exams as cheating, and ban its use even though the Ministry of Education encourages and permits it. Andrew Tideswell says in his opinion students using the technology during an exam gain approximately an extra fifteen minutes in a three hour exam, over students who don't use it.

For the most part, a critical number of the participant teachers are using the technology, and it is believed there will be a snowballing effect in 2006. Evidence for this is the increased number of enquiries facilitators are receiving from their science teacher colleagues, along with more calls for training and demonstrations.

Another issue was the different internal structures within each school. Initially, all facilitators had planned to trial a common set of activities during the year. However, because some schools did not teach the same content or the facilitators did not teach a particular Year group, the trial did not go ahead. Some of the most significant findings occurred in Year 12 mathematics, yet not all facilitators taught a Year 12 class.

Changes occurring in MOTIS teachers and their practice:

Because teacher change rather than student learning is the focus of this project, a controlled longitudinal study of academic achievement is not included. However, adequate evidence of increased student learning is developing, and is illustrated in the teacher stories to follow. Stories show that learning in a junior Statistics class, and an interactive geometry class, are significantly enhanced. There is also evidence of increased student engagement and deeper understanding of the subject matter, which are predicted to lead to further learning gains.

Increased integration between Mathematics, Science, and ICT is also happening. Extra training workshops have been provided by facilitators to three of the four schools' science departments, and science and mathematics departments are cooperating in the purchase and use of mobile technology. At WHS, the departments shared the cost of extra graphic calculators.

Importantly, MOTIS participants found that the technology was delivering the pedagogical change it promised. The following **Teacher Stories** show instances of greater student engagement, deeper student understanding, and better connectedness with the wider world.

Students from WHS using HHT.

MOTIS also found that the technology has made some aspects of the mathematics curriculum redundant, with junior students easily able to surpass previous learning expectations in Statistics.

The Teachers' Stories

Teacher A

Teacher A teaches in a decile three, co-educational high school, and looked at the implications of using Flash enabled graphic calculators, TI-83 Plus with Flash software, for the Teaching and Assessment of Mathematics AS 90289 *Achievement Standard 2.6 – Simulate Probability Situations and apply the Normal Distribution.*

A Flash enabled graphic calculator is a significant advance over an earlier generation device as it can be loaded with applications to support the teaching and assessment of a particular topic. NZQA allows for the use of such applications in internally assessed Achievement Standards.

The current Standard, and suggestions for using the TI-83 Plus graphic calculator in teaching and assessing the Standard are given in an appendix at the end of this document.

The experience of apparatus in probability simulations is a desirable part of learning and understanding about Probability. Current theory advocates a progression in teaching and learning Number, from manipulating, to imaging, to strategy development and algorithm, and the ability to move between these representations of Number and its processes.

A relevant question is whether the existence of Flash software such as **Probability Simulator** on newer technology graphic calculators provides imaging of a useful kind, that enables some learners to better understand the numerical computations and algebraic representations of Probability.

Use of Apparatus in the Simulation Component:

At Achievement level, there are problems with the availability of Flash memory and Flash applications. Although the Standard is internally assessed and apparatus can be used, a high school mathematics department may lack sufficient apparatus to enable an entire Year 12 class to simultaneously perform the practical component of the assessment. If sufficient apparatus is available, there may be management and organisational issues for the classroom teacher. Time, space, and noise can be problematic.

Student using sonic motion sensor to measure the speed of the balloon.

Ways to deal with this include completing the practical component at home. However, this solution raises issues around cheating and authenticity. Alternatively, assessments could be staggered, which could heighten the risk of students tested first, colluding with students to be tested later. Staggering would also intrude on teaching time.

Other possible approaches include getting the students to design and perform their practical simulation around the use of a random number generator from a table or calculator; or to teach the class to use a spreadsheet to perform the simulation, which would require the booking of a specialist room for the teaching session, and for the practical component of the assessment. The technical competence of the student using the spreadsheet package could be an issue, especially if practice time is limited.

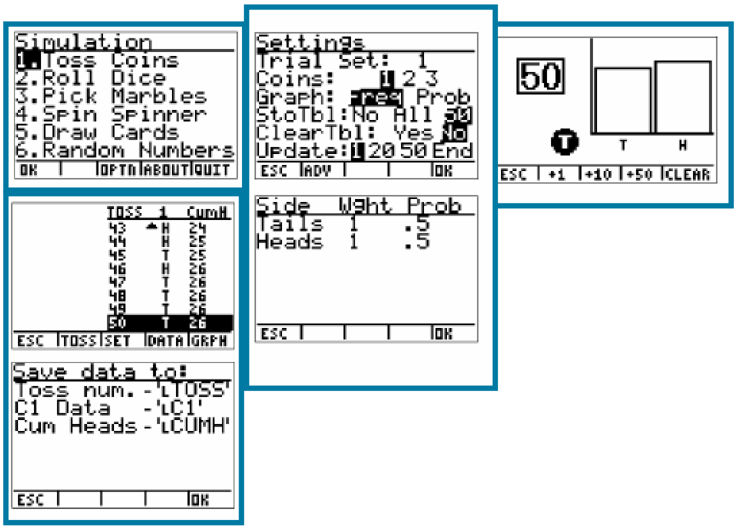
Students trained in using the flash-memory of hand held technology were adept at formulating and providing solutions to problems involving theoretical probability. They preferred to use the Probability Simulator app. to perform probability experiments, which freed up the teacher's time for teaching rather than the resource management. Verification was also more robust, as teachers could ask for screen dumps of the students' simulation data, if required.

The sophistication of the '**5:randInt(** command allows for a tailored sample space, and number of trials to be entered efficiently. The command was easily mastered, especially if the student simultaneously ran the **Catalogue Help** application, which was a programme that prompted the student with the syntax of any command or function they were operating. Given the **5:randInt(** option, many students took it and produced an adequate probability simulation.

The student was also required to describe their simulation in a way that it could be repeated. This could be problematic for students with reading or language difficulties if they have performed the simulation using standard printed random number tables, and the sample space is convoluted or a combination of events is required. A candidate using the **5:randInt(** option was significantly advantaged as they only had to name the model of calculator they used, and write the relevant command line.

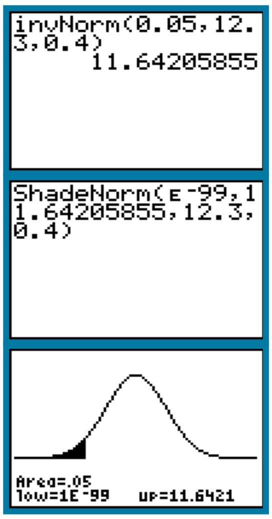
A significant subgroup of students did not use the **5:randInt(** option but instead used the **Probability Simulator** application. The students used the coin toss, spinner, marble draw, card pick or dice throw options to produce a corresponding visual image of the mathematical object. This made the connection between the numbers, graphs and tables produced by the calculator, and a picture of the simulation occurring as though the student was manipulating the object

The student described their simulation by stating the application and settings used.



These screenshots illustrate the degree of versatility of the Probability Simulator application. The student selected the apparatus he/she wanted to emulate, and selected the number and sequence of trials. Results were displayed in table and relative frequency graph forms. The entire data set was stored in the statistics list editor of the calculator. As the trial progressed, the student sees the spinner spin, or the coin flip in the air.

Pedagogical Implications for the Achievement Standard:



One issue was that the Achievement Standard did not consider the high specifications of the hand held technology that was available. Problems that were once considered to be at Excellence Level in part due to the complexity of the manipulations required were despatched with ease by students using the technology.

An example of this is given below:

The time taken for a P.E. class to run 100m was found to be normally distributed with a mean time of μ = 12.3 seconds, with a standard deviation of σ = 0.4 seconds. Find the probability that a randomly chosen student from a group will run 100 m. in less than 11.64 seconds (to 4 s.f.)

(author: i.e.. Find x such that $P(X \leq x) = 0.05$, for $\mu = 12.3$, $\sigma = 0.4$)

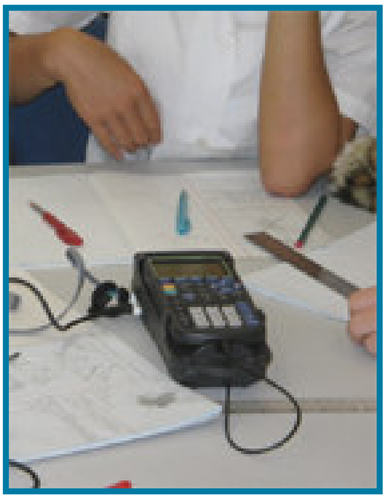
This was solved as illustrated. There was a five percent probability a randomly chosen student from the group will run 100 m. in less than 11.64 seconds (to 4 s.f.)

Using paper-based format, the student would typically be required to have between six and twelve lines of working, combined with the use of Z-tables, and the use of two processes of symmetry. The technology-based alternative still requires the student to understand the problem, but they are not impeded from completing the task because of the time spent on trivial manipulations.

With the technology, the examiner is able to examine the student on a broader range of questions. This requires the student to display a greater range and understanding of mathematical processes.

Other Teacher Stories:

Teachers B:



A datalogger.

Teachers B teach at a co-educational decile 3 school. Two teachers taught the unit of work.

The four-week topic period covered simulations of probability situations, and the application of Normal Distribution. Graphic Calculators were used extensively over that time.

For the Normal Distribution work students initially used the Normal Curve tables. Once the basic understanding of the concepts involved were understood, students were introduced to the distribution functions of the TI calculator. Students and teachers were impressed with the ease and speed at which results could be obtained. In the assessment for this internal Achievement Standard, only two students preferred to use the tables.

For simulations, students were introduced to the random functions available on the **TI Prob** menu. This enabled simulations involving large samples, and avoided tedious mechanical repetition and procedures. For example, in the simulation called Lightning Strike, which involved a four-engine plane flying through a thunderstorm, over 50 trials were generated easily. This allowed meaningful interpretation. In the final assessment, all the students used the probability functions to simulate the situation (Fair Cop), as well as the TI calculators for the Normal Distribution questions.

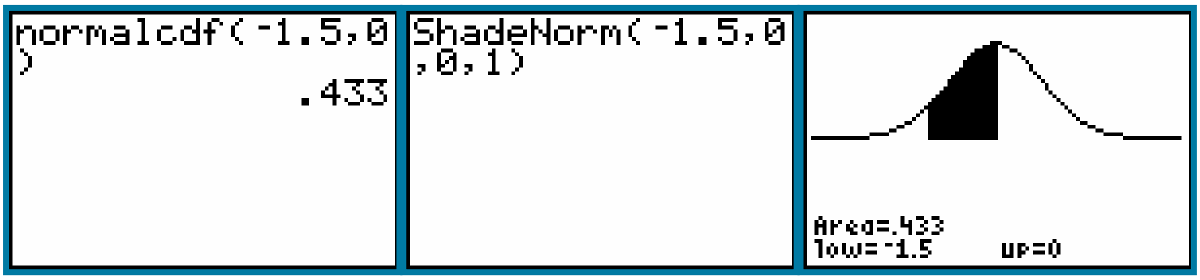
Teacher C:

Teacher C teaches at a decile 9 co-educational school:

“I found my class was motivated by being able to use the technology to calculate the Normal distribution values, rather than looking up the tables. Pupils seemed to get caught up in a desire to want to understand how to master the technology. In my class of less able pupils, many experienced success with this part of the curriculum as the calculators provided a more relevant means of obtaining the answer than the tables. The students found it easier to use the graphics calculators than the tables. Being able to quickly draw the graph of the distribution was a feature which added interest to the topic.

Using the random number generator was a lot quicker than any other method of obtaining random numbers, and took the tedium out of the task. It was also easier for me to mark as I could give the class the same seed to start with."

Author's e.g.: find P(0 <Z< $^{-}1.5$), and calculator solution:



Summary:

It was evident that a student using a Flash enabled graphic calculator for AS90289 was at a significant advantage over a candidate using a conventional graphic calculator:

- Simulations were be completed more quickly
- Simulations were more easily described to the examiner
- Problems involving the Normal Distribution were being completed without recourse to Z-tables and the risk of misreading them
- Time saved by a candidate in using the technology at Achievement level was invested in attempting the Merit and Excellence level questions
- Problems involving Z conversions, inverse Normal problems, and compound Normal problems were solved with ease. The candidate still needed to be able to frame the problem, but the solution, in its graphical and numeric forms, was produced instantly
- The content of Merit and Excellence-level questions became more accessible, with a reduced chance of simple computational errors or errors of syntax in written working
- There was a net overall saving in teaching and assessment time for the topic, which was reinvested elsewhere in the year's programme.

Recommendations:

The current Standard and its assessment should be updated as Flash enabled calculators become more widespread in use in that:

- The Flash enabled graphic calculator has reordered the levels of complexity of problems, and the problems need to be redesigned accordingly
- A significant component of traditional Normal Distribution problems relate to reading and interpreting tables. Some thought should be given to whether this skill is still relevant with respect to Z-tables, and whether the examination of table reading as a skill belongs in this or any other Standard. It may be, for instance, that table reading belongs in mathematics, but might be assessed in a completely unique new Standard, perhaps based on mathematical processes
- A greater weight might usefully be placed on requiring a candidate to frame a problem, and to interpret its solution.