A Integrated Approach to the Teaching and Learning of Science and Mathematics Utilising the TI-Nspire^{TM}

An Analysis of Irish Secondary Classrooms

Research Report Year 1: 2009-2010

Dr. Jennifer Johnston, Dr. Máire Ní Ríordáin,
Dr. George McClelland & Prof. John O'Donoghue

National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL), University of Limerick

The Research Team

Dr. Jennifer Johnston
Senior Projects Officer in Teaching and Learning – Physical Sciences,
National Centre for Excellence in Mathematics and Science Teaching and Learning,
(NCE-MSTL)
University of Limerick.
Email: jennifer.johnston@ul.ie

Dr. Máire Ní Ríordáin
Head of Education,
St. Patrick's College,
Thurles
Email: mniriordain@stpats.ie

Dr. George McClelland
Director - Science
NCE-MSTL,
University of Limerick.
Email: george.mcclelland@ul.ie

Professor John O'Donoghue
Director - Mathematics
NCE-MSTL,
University of Limerick.
Email: john.odonoghue@ul.ie

Acknowledgements

We would like to sincerely thank all schools, principals, teachers and students who participated in this study. Without their valuable contribution we would not have been able to complete this significant research.

We would like to thank Texas Instruments for providing the technology resources and training assistance, which were an integral part of the study.

We would like to thank and acknowledge Discover Science and Engineering for their financial support towards this research project.

We are also very grateful to our colleagues at the National Centre for Excellence in Mathematics and Science Teaching and Learning who assisted in the classroom observations and the CPD sessions.

Participating teachers

The teachers who participated in this research project are well regarded teachers and perform excellently within the confines of the Irish Educational system. The Irish Education system operates on a centralised education model and contains a very descriptive syllabus. The teachers are being rewarded by the system that demands results. Local innovation takes additional energy and the NCE-MSTL commends the effort and time the participating teaching gave to this project. The NCE-MSTL would like to reiterate the fact that the findings from this project are preliminary and these well respected teachers are already successfully meeting the demands of the Irish Educational system.

Executive summary

Introduction

The project focus is on the integration of science and mathematics through the use of the TI-Nspire™. The pilot study designed, developed and implemented innovative lesson plans in 1st Year Junior Certificate science classes. Six secondary school science and mathematics teachers participated in the pilot study. The lesson plans were designed and developed by the NCE–MSTL Senior Project Officers and the researcher, with the support and feedback of the teachers. The purpose of this project is to improve the science and mathematics experience at Junior Cycle through the integration of science and mathematics lessons utilising the TI-Nspire™.

Aim of the study

- To design, implement and evaluate a collaborative approach to develop conceptual understanding in science and mathematics at Junior Cycle.
- To develop, implement and assess the use of technology integrating mathematics and science teaching and learning.
- To design and evaluate innovative lesson plans which integrate Junior Cycle science and mathematics topics which promote conceptual understanding.

Methodology

The innovative project was piloted in second level schools in the southwest of Ireland.

- 3 pilot schools and 6 teachers.
- 1 mathematics teacher and 1 science teacher worked in collaboration, with each other and the NCE-MSTL team in each of the participating schools.
- Teachers/schools provided with full set of TI-Nspire™ calculators/data loggers.

- The active research of the integrated science and mathematics lesson plans took place during March/April ‘10.
- 3 weeks active research lesson cycles.
- Topic: Distance, Speed and Time.

Project Evaluation

The project was evaluated by the following means;

- Teachers Reflective log
- Observers log
- Focus group meeting
- NCE-MSTL observations

Key findings

Overall, teachers found lessons enjoyable and they all had a very positive experience.

Science teacher

- Inquiry based approach some issues with implementation.
- Lesson plan length and sequence.
- Time constraints.
- Some tasks done very well by individual teachers.
- Technology concerns – motion sensor problems.
- Car construction problems.

Mathematics teachers

Liked the tasks but found it difficult to adapt to the new style of teaching, they could see the benefits for pupil learning.

- Missed out on some key concepts (e.g. scale/ units, positive/negative slope).
- Time constraints - too many tasks per lesson.
- Little discussion.
- Some tasks done very well by individual teachers.
- Technology concerns.
- Poor use of mathematics language.

Students

- Students engaged, interested and enjoyed the activities-engagement with balloon rocket car excellent.
- Students responded well.
- Teacher talk vs. student activity.
- Enjoyed the use of technology.
- Developed an understanding of the relevance of mathematics *for* science and science *for* mathematics.

Next steps

- All teachers want to continue with the project
- The model of integration utilised in this study was ambitious with several new concepts being introduced at the same time (technology, new style of

teaching, integration of topics/subjects). Moving forward, the teachers have developed skills in the use of the TI-Nspire[TM]. We aim to build on their skills in being able to use and implement the technology confidently and effectively.

- There is a conflict between time constraints and the positive student learning experiences. These issues along with the Inquiry Based Learning (IBL) approach will be examined and investigated further in year 2.

Contents

List of Figures/Tables

Abstract

The aim of this study was to design, develop, implement and evaluate an integrated approach to the teaching and learning of science and mathematics in second level schools in Ireland. This was undertaken through the integration of a handheld graphic calculator known as the TI-Nspire™ into first year classes (age 12 -13 year olds) of science and mathematics. This collaboration was assisted by the development and implementation of specific lesson plans that integrated the teaching and learning of both subjects. The content of the lesson plans supported the development of a deeper conceptual understanding of the topics of speed, distance and time. The focus within the science lesson plans was on the mathematics underpinning the science concepts. By using data generated in the science lessons it facilitated an increased use of contexts and applications in the mathematics lessons that enabled students to relate mathematics to everyday experiences. It was intended that the students experienced science and mathematics in a new way, using technology and examples that had a real-life application, and accordingly it facilitated a deeper understanding of key science and mathematical concepts. An inquiry-based approach was supported in the science lessons, with the mathematics lessons promoting a teaching for understanding method. Action research was the central methodology of this study. The study was evaluated through a teachers reflective log book and teacher interviews. The qualitative data reports the teacher's experience of the project. The integrated science and mathematics lessons were observed by an independent observer. The observer recorded how the lesson plans were implemented and assessed if the learning outcomes were achieved. This report focuses on the specific integration of speed, distance and time through the examination of the content and teaching approaches in the interdependent lesson plans utilised in the science and mathematics lessons. A key outcome of this project was the development of specific lesson plans to help facilitate the integration of both subjects.

Introduction

The aim of this study was to design, develop, implement and evaluate a collaborative teaching approach to develop students' conceptual understanding in science and mathematics at second level education. This was assisted by the development and implementation of specific lesson plans (3 double science lessons and 4 single mathematics lessons) that integrated the teaching and learning of both subjects utilising technology. The implementation of the collaboration between the science and mathematics teachers was facilitated by the use of technology – the TI-Nspire^{TM} (graphical calculator and data logger) that allowed real-life data to be collected, analysed and explored both in the mathematics and science lessons. The mathematics and science teachers involved in this project were supported in designing, implementing and evaluating innovative lesson plans which integrated Junior Cycle (lower second level education) science and mathematics topics which promote conceptual understanding. By improving the students' level of conceptual understanding of science it is envisaged that this will improve their mathematics ability; by improving students' mathematical skills it will facilitate the development of their conceptual understanding in science.

Background to the project

Increasing the uptake and the performance of second level students mathematics and science, especially higher level mathematics and physical sciences, has been identified as a national priority in Ireland (NCCA 2008; EGFSN 2008). In the OECD PISA assessments (2006), Ireland ranks 14th and 16th respectively out of 30 OECD countries in terms of scientific and mathematical literacy (Educational Research Centre 2007). 'Modest levels of attainment in mathematics at junior second level are feeding into poor performance and low levels of interest in higher level mathematics' (NCCA 2008, p.17). The Task Force on Physical Sciences (2002) highlights the serious concerns about mathematics and science uptake and the low intake into the Science, Engineering and Technology courses at third level education.

Irish Education System

The Irish Education System is divided into three levels as follows;

- Primary education
- Secondary education
    - o Junior Cycle (3years + state exam – Junior Certificate)
    - o Transition Year (gap year)
    - o Senior Cycle (2 years + state exam – Leaving Certificate)
- Third level education

Education is compulsory for children in Ireland from the ages of six to 16 or until children have completed three years of second-level education.

Project Maths – Sept 2011

Projects Maths is a new mathematics syllabus introduced into both the Junior and Senior Cycles in September 2011. The main aims of Project Maths are as follows;

- To provide for an enhanced student learning experience and greater levels of achievement for all,
- Much greater emphasis will be placed on student understanding of mathematical concepts,
- Increased use of contexts and applications that enable students to relate mathematics to everyday experience.

Therefore, given the increased focused within the new mathematics syllabus on increased understanding of concepts and use of real life applications this research project is timely and relevant.

Why this study is important

One of the main aims of the NCE-MSTL is to conduct best practice research in science and mathematics teaching and learning as required by the remit of the national centre defined by the Higher Education Authority (HEA). In light of this, an evidence-based research project was undertaken at the NCE-MSTL to address this national problem in science and mathematics. This project involved the integration of science, mathematics and technology through active learning lesson plans which were developed to include mathematics support integrated into physical sciences with the use of technology. It was topic driven, evidence-based research.

The research context

The study was piloted in 3 schools in the Munster region. The following is a description of the 3 schools. Pseudo names are used to protect the schools identity. The study focused on 1st year students at second level education (approx. aged 12-13 years old) and this influenced the selection of teachers participating in this research project. Post-primary schools in Ireland are also known as second level schools. There are three types of school in Ireland: secondary schools, community and comprehensive schools, and vocational schools. The differences are mainly due to the management structure of the schools. All schools follow a set national curriculum in all subjects.

School 1: St. John's Secondary School

St. John's is situated twenty minutes from city 'A' (population ≈ 100,000). This rural coeducational *vocational* post-primary school offers full-time education from first year to Leaving Certificate level (final state examination at second level), ranging in age from twelve to eighteen years. Currently one of the fastest growing post-primary schools in Ireland, the school has built up a national reputation in the delivery of a high quality and progressive educational programme, particularly with its emphasis on the sciences, languages, information and communication technology and overall commitment to innovation, in all that it does. Technology plays a major role in this school with every student owning a laptop and the availability of wifi and data projectors in every classroom. There are 824 students enrolled in the school (413 boys; 411 girls). The participating first year mathematics and science class had 27 students.

School 2: St. Ann's College

St. Ann's College is situated in city 'A'. This all-girls *secondary* post-primary school offers full-time education to girls from first year to Leaving Certificate level, ranging in age from twelve to eighteen years. The school has developed a reputation of providing education for girls from a variety of social class backgrounds in the city. The school is committed to delivering high quality teaching and a holistic learning experience. There are 252 girls enrolled in the school. The participating first year mathematics and science class had 24 students. This school lack basic technology and there are two to three laptops available for the teachers to share. The science lab has a data projector.

School 3: St. Pat's Secondary School

St. Pat's is a co-educational vocational post-primary school situated in a large town 25 minutes drive from city 'A'. It offers full-time education to first year to Leaving Certificate level. There are approximately 450 students enrolled in the school. The participating first year mathematics and science class currently had 24 students. This school has basic technology, the science lab has a data projector and both mathematics and science teachers involved in this study owned their own laptop.

Aim of the Study

The aim of the research project was to design, develop, implement and evaluate a collaborative teaching approach to develop students' conceptual understanding in physics and mathematics at second level education.

Objectives

The overall objectives of the study were as follows;

- By improving the students' level of conceptual understanding of science it is envisaged that this will improve their mathematics ability.
- By improving the students' level of conceptual understanding of mathematics/science it is envisaged that this will improve the uptake of Junior Cycle Science and Mathematics at higher level and will improve their teaching and learning experience.
- To develop the participating teachers skills on the use of the technology.
- To develop the participating teachers skills on innovative lesson plans.
- To improve the students' learning experience and provide them with feedback on their understanding through the use of technology.
- The final objective is to produce a number of evidence based good practice applications to hand to teachers for use in the teaching and learning of maths concepts and application in science.

Methodology

The research focus of this project is on Inquiry Based Learning (IBL) and pedagogical enhancement utilising technology, and with the aim of improving students' conceptual understanding of motion. The overarching methodology employed in this study was action research. It was chosen as the methodology because it is useful when investigating how to improve learning and take social action (McNiff and Whitehead 2006). This innovative project was piloted in three second level schools in the southwest of Ireland. One mathematics teacher and one science teacher worked in collaboration, with each other and with the NCE-MSTL team, in each of the participating schools. Teacher training in the use and integration of the technology into the teaching and learning of science and mathematics took place from September '09 to December '09. The active research of the integrated science and mathematics lesson plans took place from January '10 to March '10. First year post-primary education students of mathematics and sciences defined the context of the study. The following considerations applied:

- Every student in the classes of the three selected schools along with the teachers was provided with a TI-Nspire™ handheld graphic calculator and data logging equipment.
- Lesson plans that were applicable to the syllabus were developed by the NCE-MSTL senior project officers, with the support and feedback of cooperating group of teachers and the assistance of an appointed researcher, under the direction of the NCE-MSTL co-directors.

- The teachers of the selected schools were active researchers in implementing the lesson plans in their classrooms.
- Continuous support and training was provided for all teachers involved either in the NCE-MSTL or in the school.

How the study operated

Potential schools and teachers were identified in September 2009. Final selection took place in October 2009. Subsequently all teachers involved in the study undertook professional development in the use and implementation of the TI-Nspire™ throughout November and December 2009. The active research of the integrated science and mathematics lesson plans took place from January '10 to March '10. Each science and mathematics teacher was supplied with a Texas Instrument TI-Nspire™ handheld graphic calculator and the appropriate software to support the development of the lesson plans for the full school year '09/'10. Each school was provided with a full set of TI-Nspire™ handheld graphic calculators for the class group (1st years) participating in the research project for the full school year '09/'10.

Benefits of participating in the project

The benefits for the schools and the teachers to be involved in such an innovative project are as follows;

- It was an opportunity to develop lesson plans related to real-life applications of mathematics consistent with the new Project Maths syllabus.
- It was an opportunity to develop how to integrate technology into science teaching, while being supported by NCE-MSTL.
- Innovative TI-Nspire™ equipment loaned to each school for the year free of charge.
- It was an opportunity to foster collaborative teaching across subjects within each school and in a community of practice.
- It was an opportunity to participate in action research as part of the NCE-MSTL.

Instruments for data collection

Qualitative data on the teachers' experience of the project was collected through a teachers reflective log book and teacher interviews. Data was collected by an independent observer on how the lesson plans were implemented. All mathematics and science lessons were observed, however due to time constraints a different individual observed each lesson. The observers also assessed whether or not the learning outcomes for each lesson were achieved.

Science Approach

Research has highlighted the importance of building the development of scientific concepts and skills on concrete experience (Rosenquist & McDermott 1987). The science lesson plans were designed to promote the constructivist approach through the use of Inquiry Based Learning (IBL) (Piaget 1928; 1952). Brooks and Brooks (1993) stated that meaningful learning occurs when new knowledge and skills are embedded in context, and students make connections among idea. The lessons were designed to engage the students in the active use of concepts in concrete situations. Everyday objects and experiences from their everyday lives were used in the science lessons. The inquiry based approach helps the students close the gaps in their knowledge through repeated exercises that are spread out over time and are integrated with the subject matter of both the science and mathematics courses. To help the learner assimilate abstract concepts, it is essential to engage the learner's mind in the active use of the concepts in concrete situations (Arons 1990). The concepts must be explicitly connected with immediate, visible, or kinaesthetic experience. Furthermore, the learner should be led to confront and resolve the contradictions that result from his or her own misconceptions (Arons 1990). There are several learning difficulties that are involved in the development of the concepts of distance, speed and time. Arons (1990) states that a powerful way of helping students master a type of scientific reasoning, is to allow them to view the same reasoning from more than one perspective. An effective way of reaching many students who have difficulty in relating position on a graph to motion is to lead them through direct kinaesthetic experience. Giving them problems in which they must translate from the graph to an actual motion and from an actual motion to its representation on a graph.

Distance – Speed – Time: Some Underpinnings

There are several learning difficulties that are involved in the development of the concepts of distance, speed and time. Many of these learning difficulties can be found in the 'Teaching Introductory Physics' by Arons (1990). Kinematics can be represented through ratios and division. It can also be represented through graphical representations. 'A powerful way of helping students master a mode of reasoning is to allow them to view the same reasoning from more than one perspective' (Arons 1990). It is necessary to ask questions that lead the students to articulate the interpretations and explanations in their own words (Arons 1990). Many students have great difficulty giving verbal interpretations of ratios or of graphs, for example. Arons (1990) recommends that in each encounter the students should have to interpret the representations in their own words. It is impossible to deal with back and forth motion without discriminating between positions, changes in position, and distances travelled by the body (three different concepts to which the term 'distance' is frequently indiscriminately applied) (Arons 1990). An effective way of reaching many students who have difficulty in relating position on a graph to motion is to lead them through direct kinaesthetic experience. Giving them problems in which they must translate from the graph to an actual motion and from an actual motion to its representation on a graph. Students should be given the opportunity to solve problems both graphically and algebraically, not just in one mode. This gives the students time to review basic ideas and at the same time connect these ideas with a familiar physical situation. Arons (1990) states that mastery of physics develops slowly as the concepts mature in the mind through use and application.

Mathematics Approach

The mathematics lesson plans were designed to promote a teaching for understanding approach through the use of rich mathematical tasks which provide students with the opportunity of specializing and generalizing in the mathematics class (Mason 1999). A new mathematics curriculum, *Project Maths*, is being introduced in all post-primary schools in Ireland. Emphasis is being placed on student understanding of mathematical concepts, with increased use of contexts and applications that will enable students to relate mathematics to everyday experiences (Project Maths 2008). The mathematical approach adopted in this research project is consistent with the new mathematics curriculum being introduced in order to provide teachers with the opportunity of developing skills for implementing *Project Maths*.

Rich Mathematical Tasks

Mathematical tasks that are referred to as 'rich' are those that are most likely to engage students positively and effectively with their mathematical learning. Rich mathematical tasks were a critical component of the pedagogy that underpinned the mathematics element of the TI-Nspire project. The importance of incorporating 'rich mathematical tasks' into the teaching and learning of mathematics has been highlighted by many researchers (Boaler & Staples 2008). They can be described as incorporating some of the following characteristics (Ahmed 1987):

- Are accessible and extendable.
- Allow individuals to make decisions.
- Involve students in testing, proving, explaining, reflecting and interpreting.
- Promote discussion and communication.
- Encourage originality and invention.
- Encourage "what if?" and "what if not?" questions.
- Are enjoyable and contain opportunity to surprise.

By employing rich mathematical tasks it allows students to find something challenging and at an appropriate level to work on (Swan 2005).

Specializing and Generalizing

Within the mathematics element of this project we are also concerned with how students approach problem solving. Mason (1999) emphasises the central core of mathematics as *Specializing* (constructing particular examples to see what happens), and *Generalizing* (detect a form; express it as a conjecture; then justify it through reasoned argument). Specializing involves trying specific examples in order to develop an understanding in relation to what a mathematical concept is proposing. Therefore, the purpose of specializing is to gain clarity as to the meaning of a question or statement, and then to provide examples which have some general properties in common – the process of generalizing (Mason 1999). Generalizing has to do with noticing and describing properties common to several mathematics questions/problems. The mathematics teacher should employ questions which encourage students to think deeply about the problem/examples presented. By looking at the examples that the students have completed, they should try to see what is common among them, guided by what the problem or text asks for or states. Generalizing is more difficult, because it involves noticing or stressing things that are common to numerous examples, and ignoring features which seem to be special to only some of them (Mason 1999).

The Interdependent Lesson Plans

The active research of the integrated science and mathematics lesson plans took place during March and April, 2010, over the course of three weeks. What follows is a description of each of the lesson plans and they are presented in the order that facilitated the integration.

■ Science 1
■ Maths 1
■ Science 2
■ Maths 2
■ Science 3
■ Maths 3
■ Maths 4

Figure 1 illustrates the lesson plans sequence

Science Lesson 1

The first double lesson (see Appendix A) attempted to engage the students in the ideas and concept of motion. The teacher facilitated a discussion on speed drawing on their experiences from everyday life. With the teachers as the facilitator, the students would generate ideas on how to measure speed and how it can be represented. With household material the students built their own balloon rocket cars. The purpose of the balloon rocket car was to help the students take ownership in the design of their cars and it was used to aid the development of the concepts of distance, speed and time over the 3 weeks. At the end of the first lesson the student would have built and tested their balloon rocket cars and would have also generated ideas of how to measure speed using their cars, the TI-Nspire™ and the motion probe.

Outline of Science Lesson 1

In the lesson students

- Identified the quantities needed to measure speed (distance/time).
- Described how to measure speed.
- Built and tested balloon rocket cars
- Demonstrated the ability to measure the speed of the balloon rocket car.

Figure 2 illustrates an example of a balloon rocket car

Mathematics Lesson Plan 1

It was anticipated that students may have some experience of drawing and interpreting graphs from previous science lessons and from encountering them in everyday contexts such as in opinion polls, weather reports, etc. However, the teachers involved in this research project felt that it was essential that students' basic graphical skills were well developed to ensure that the implementation of the other mathematics and science lesson plans were successful. Therefore, the purpose of the first mathematics lesson plan (see Appendix B) was to provide students with key skills required for drawing graphs. Student learning outcomes from this lesson included:

- Drawing axes and labelling them appropriately
- Interpreting graphical information
- Plotting coordinate points on a graph
- Connecting coordinate points

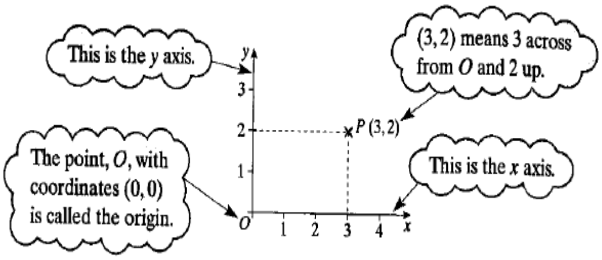


Figure 3 Illustrates example of graph used in mathematics lesson 1

Science Lesson 2

The second science lesson (see Appendix C) began with a recap of how speed could be measured leading to a discussion on how speed could be represented. Using their hand made cars they were asked to predict, analyse and test their ideas about motion. Through the aid of the motion probe and the TI-Nspire™ they tested their predictions and collected data on the handheld. Using the data generated the students drew a distance-time graph in their lab copies. With the aid of several other distances-time graphs the students were challenged to apply their experience with the balloon rocket cars and their new knowledge to the interpretation and explanation of new graphs. Thus, to generate the relationship between distance, speed and time from their experience.

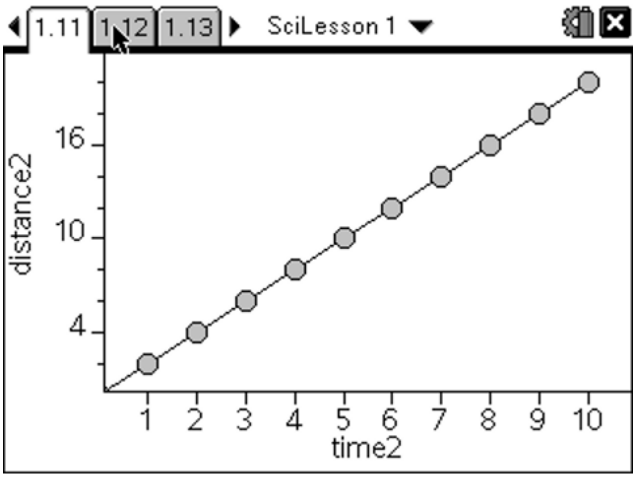


Figure 4 illustrates an example distance-time graph on the TI-Nspire™

Mathematics Lesson Plan 2

The purpose of the second mathematics lesson plan (see Appendix D) was to develop further students' understanding of graphical concepts in relation to travel graphs. Key student learning outcomes from the lesson included:

- Stating the scale/units being used
- Developing an understanding of speed - straight lines correspond to motion with a constant speed; the slope of the line indicates the value of the speed
- The steeper the slope, the faster the speed; a horizontal line shows the object at rest – indicates no movement at all (slope = 0 = speed)

- Lines with a positive slope indicate movement away from the starting point
- Lines with a negative slope indicate movement back towards the starting point

Mathematics Lesson Plan 2 also incorporated the use of data generated from the previous science lesson to draw distance-time graphs, while also encouraging discussion and explanation of variations in their findings in relation to the key concepts developed.

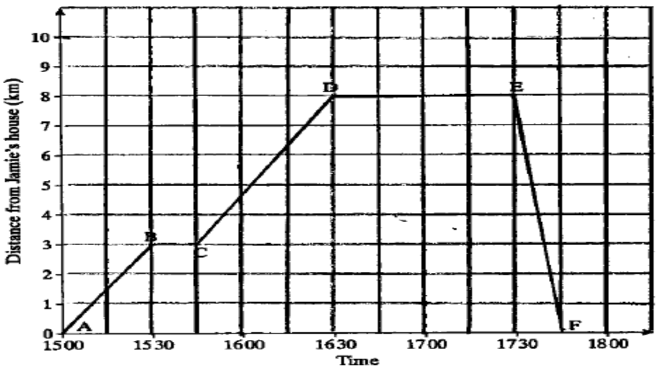


Figure 5 illustrates an example of a distance-time graph used in mathematics lesson 2

Science Lesson 3

The final double science lesson (see Appendix E) involved the students actively acting out their motion using the TI-Nspire^{TM} and the motion probe (CBR2). In the previous mathematics lesson students examined questions in relation to the direction of the motion and the slope. The active experience of acting out this motion helped the student connect the graph on paper to actual motion. For example, being able to distinguish between positive slopes, negative slopes, no motion etc., was possible through all concrete experiences. Thus they developed further the relationship between distance, speed and time by predicting and acting out the motion of the graphs.

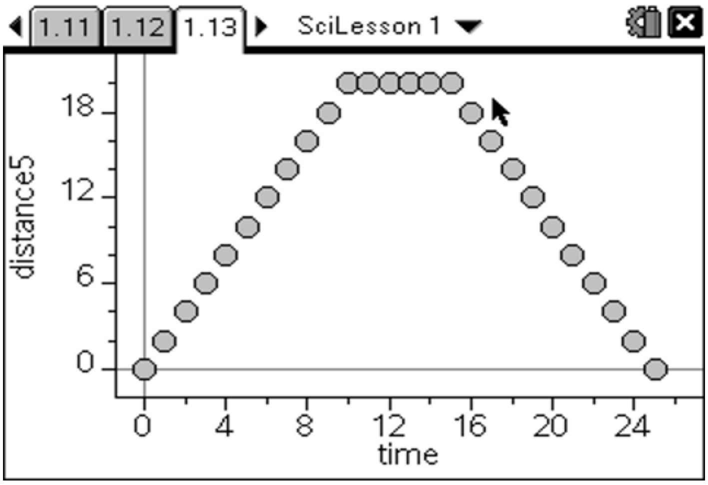


Figure 6 illustrates an example of a distance-time graph on the TI-Nspire^{TM} created from mapping out the motion using a motion probe (CBR2)

Mathematics Lesson Plan 3

The overall aim of the lesson (See Appendix F) was that students themselves would generate the average speed formula through completion of mathematical rich tasks concerned with speed, distance and time. These tasks incorporated real-life applications, thus making the material relevant for student learning.

Mathematics Lesson Plan 4

The last mathematics lesson plan (See Appendix G) was concerned with furthering students' understanding of the concept of average speed through engagement in the different sets of distance and time data they had collected in the science lesson. Students were required to demonstrate key learning outcomes acquired from the previous science and mathematics lessons, while appreciating the application of mathematics in science and real life applications.

Findings

The following section will summarise the key findings emerging from the teacher's reflective journals and from the lesson observations. These are presented from the perspective of the subject area teachers i.e. science and mathematics, the students and technology concerns.

Teacher Reflections

From the mathematics teachers' reflective journals it is evident that the teachers thought the tasks incorporated into the mathematics lesson plans were appropriate and consistent with the learning outcomes stated. However, they strongly felt that there were too many tasks per lesson which had repercussions for time management and facilitating the integrated teaching approach. Similarly, the teachers felt that there was too much time between the specific mathematics lesson plans (a week on average) and they felt that it would be better if they were closer so as to facilitate reinforcement of previous learning. Although the teachers concerned liked the tasks presented in the lesson plans they found it difficult to adapt to the new style of teaching. On a positive note, the teachers could see the benefits of this style of teaching for student learning and understanding, but it came at the cost of less of syllabus coverage and justifying spending such an amount of time on 'just one topic'.

In general, the inquiry based approach of the science lessons was not adopted as expected by the authors. Teachers found it difficult to give the students enough time to respond and come up with their own ideas and like the mathematics lesson they tended to be teacher dominant rather that student centred.

Both the science and mathematics teachers involved in this research project found positive outcomes for student learning and understanding. The teachers' reflections portray students as engaged, interested, responding well and enjoying the mathematical and science activities. In particular, engagement was highly correlated with building, designing and personalising the balloon rocket car, while working collaboratively with peers. Similarly, the students responded well to the introduction of technology into the teaching and learning of the subject areas, ensuring relevance to their elevated use of technology in their personal lives. Moreover, the teachers felt that the integrated approach helped to develop students' understanding of the relevance of mathematics *for* science and science *for* mathematics.

In terms of the teachers' capability to integrate technology into the teaching and learning of science and mathematics, they depict in their reflections a lack of confidence in their competence with the technology and accordingly this impacted on the successful integration of the TI-Nspire^{TM} into their lessons. For example, some of teachers would first do some of the tasks by hand on the whiteboard, copybook, etc. and then *repeat* the same activity using the TI-Nspire^{TM}. Unsurprisingly, difficulties arose with the technology such as batteries running out, motion sensors, etc. All expressed an interest in further training to become more competent in the use of the technology in the classroom.

Observers' Reflections

The observers' reflections on the mathematics/science lessons undertaken by the teachers reinforce the impression of didactical style teaching taking place in the classrooms. The lessons were dominated by teacher talk as opposed to the student-centred approach promoted by the lesson plans. Little discussion took place. There appears to be a difficulty in moving away from the 'norm' and 'comfortable/safe' approach utilised prior to the development of these lesson plans. The observations also expose that the mathematics teachers missed out on some key concepts within the lessons. Similarly, there was poor use of 'mathematics language' by the teachers and there appears to be a lack of confidence in their students' ability to cope with mathematical terminology and concepts. Naturally this has repercussions for students' learning and understanding for both mathematics and science. On an encouraging note, some tasks within the lesson plans were done very well by individual teachers and this is a positive aspect to take forward. The observations also noted that the students responded positively to these tasks when done well. Conclusions emerging from the observations portray a lack of confidence by the teachers in adopting the new teaching approach but when done well, student learning and understanding was enhanced. Moreover, some of the teachers did struggle with the technology aspects of the lessons but the students were competent and confident in utilising the technology, while engaging them in learning and applying knowledge.

Conclusion

All teachers involved in this pilot were highly committed and engaged throughout the project. All expressed an interest in taking part in the second phase of the project. Pilot report findings have shown that the integration of science and mathematics teaching and learning at post-primary education facilitated authentic learning experiences for the students and teachers involved in this pilot study. Difficulties arose with integrating the technology into the classroom, as well as adopting a new approach to the teaching and learning of mathematics and science at post-primary education. Moreover, the pilot study confirmed the value of collaboration between mathematics and science teachers within schools and the need and willingness of teachers to engage in continuous professional development to enhance their students' learning experiences.

References

Ahmed, A. (1987). Better Mathematics: A Curriculum Development Study. London: HMSO.

Arons, A. B. (1990). Teaching Introductory Physics. New York: Wiley.

Boaler, J. & Stapes, M. (2008). Creating mathematical futures through an equitable teaching approach: the case of Railside school. Teachers College Record, 110(3), 608-645.

Brooks, J. G., & Brooks, M. G. (1993). *In search of understanding: The case for constructivist classrooms*. Alexandria , VA : Association for Supervision and Curriculum Development.

Brooks, J. G. & Brooks, M. G. (1999). The constructivist classroom: the courage to be constructivist. Educational Leadership, 57 (3), 18-25.

Educational Research Centre, (2007). Ready for Tomorrows World: The Competencies of Irish 15-year-olds in PISA 2006. Dublin: Educational Research Centre.

Expert Group on Future Skills Needs (EGFSN, 2008). Statement on Raising National Mathematical Achievement, Dublin: EGFSN.

Mason, J. (1999). Learning and Doing Mathematics (2nd Ed.). York: QED.

NCCA (2006), Review of Mathematics in Post-Primary Education – Report on Consultation, Dublin: NCCA.

McNiff, J. and Whitehead, J. (2006) All You Need to Know About Action Research, London: Sage

Piaget, J. (1928). The Child's Conception of the World. London: Routledge and Kegan Paul.

Piaget, J. (1952). The Origins of Intelligence in Children. New York: International University Press.

Project Maths (2008). Information available at www.projectmaths.ie.

Rosenquist, M. L. and McDermott, L. C. (1987). A conceptual approach to teaching kinematics. Am. J Phys., 55 (5), 407-415.

Swan, M. (2005). Improving Learning in Mathematics: Challenges and Strategies. UK: DfES Standards Unit Publication.

Task Force on the Physical Sciences (2002). Report and Recommendations of the Task Force on the Physical Sciences. Available online at: http://www.irlgov.ie/educ/pub.htm or http://www.sciencetaskforce.ie/report

Appendix

A	**Science Lesson 1**
B	**Maths Lesson 1**
C	**Science Lesson 2**
D	**Maths Lesson 2**
E	**Science Lesson 3**
F	**Maths Lesson 3**
G	**Maths Lesson 4**

Appendix A Science Lesson 1

Enquiry Based Science Lesson 1 – Distance/Speed/Time (*Motion*)

This first year class would have encountered measurement, quantities and basic relationships to date in first year science. They have some experience of drawing and interpreting graphs (i.e. temperature and time) and ratios (i.e. density, volume). They have experience of *Motion* from their everyday lives such as movement at different speeds. Objects moving at different speed i.e. cars, trains, swimmers, runners, themselves, etc.

Whole class discussion and questioning on their understanding of motion

Could be…
A list of 10 examples from their own experience of objects that move and ask them to put in order of which is the fastest and how do they know it is the fastest object (i.e. car, train, horse etc.).

How do you measure speed? / How do represent it?

A class discussion on how speed can be measured.

Could be…
Students come up with ideas on how they could measure speed. (i.e. measuring tape, timer, TI-Nspire and motion probe).

Teacher gives the students the task of building their own balloon rocket car to investigate speed and to see if the students' ideas about how to measure speed were correct.

Class will build and test the balloon rocket cars.

Students work in groups build the balloon rocket cars and carry out simple tests to see does it work.

A class discussion on how they could measure the speed of their balloon rocket cars.
How they could make the car go faster?
How they can make the car go slower?

Relate the experience they had with measuring the speed of their own car to the everyday examples talked about at the beginning of the lesson and ask them to generalise about how speed can be measured in the different scenarios

Could be…
Simple car tests:
Check it moves freely.
Check it moves in a straight line.
Check the balloon is sealed correctly.

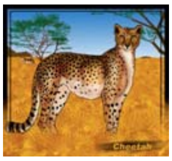
Run checks to see does the TI-Nspire and the motion probe detect the balloon rocket car and find out what gives the best signal.

Generate ideas for testing the speed of the balloon rocket car

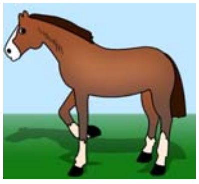
Faster and faster

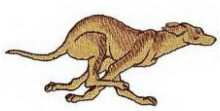
Some objects are capable of travelling at very high speeds.

Use your judgement to arrange these in order of speed, fastest to slowest.



1. **Car**
2. **Train**
3. **Horse**
4. **Jet Aircraft**
5. **Aeroplane**
6. **Cheetah**
7. **Greyhound**
8. **Human**
9. **Motorbike**
10. **Cat**





Fastest	
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
Slowest	

Balloon Rocket Car

Materials

- Plastic water bottle
- Drinking straws
- Wooden skewers
- 4 plastic caps
- Balloon
- Duct tape or masking tape
- Nail, hammer, knife, scissors.

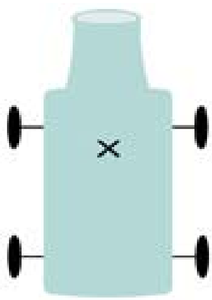
Procedure

The water bottle forms the body of the balloon car. You can start by mounting the wheels on this body.

1. Cut a drinking straw into two pieces as long as the water bottle is wide. Use strips of tape to attach them to the bottle – one near the front and one near the back. The axies for the wheels will run through these straws, so line them up carefully.

2. Use a hammer and a small nail to poke holes through the centre of four bottle caps. Cut two pieces of wooden skewer about an inch and a half longer that the pieces of straw you taped to the bottle. Push one end of each skewer through the hole in the centre of the bottle cap. If the cap doesn't fit snugly on the skewer, use some blu-tac to hold it in place. Next, thread the skewers through the straws on the bottle and attach the other wheels to the other ends. Make sure your car rolls smoothly.

3. Stretch out a large balloon by blowing it up and then letting the air out of it a few times. Next, make a nozzle. The size of the nozzle is very important. If it is too small, the air can't escape with enough force to propel the car forward. If it is too big, the air will escape too fast and the car won't go very far. Create the nozzle by taping four drinking straws together. Insert the straws into the mouth of the balloon and seal the opening by wrapping a strip of duct tape around it several times.



4. To mount the balloon/nozzle on the car, use a knife to cut two perpendicular slits (to make an X) in the top of the car about 4 inches back from the mouth of the bottle. Thread the nozzle through this opening and out through the mouth of the bottle. Leave about an inch of the nozzle sticking out of the mouth.

5. Find a hard surface, like a long table, floor. Blow up the balloon through the straws at the mouth of the bottle. Pinch the base of the balloon to prevent the air from escaping too soon. Set the car down, let go of the balloon, and watch it go!

Balloon Rocket Car Data Collection

Task 1

Create a Distance vs. Time **data table** for you car. Only include 0-5 metres data

Time (seconds)	Distance (Metres)
0	0

Task 2

Create a Distance vs. Time **graph** for you car. Only include 0-5 metres data

Appendix B Maths Lesson 1

Mathematics Lesson Plan 1

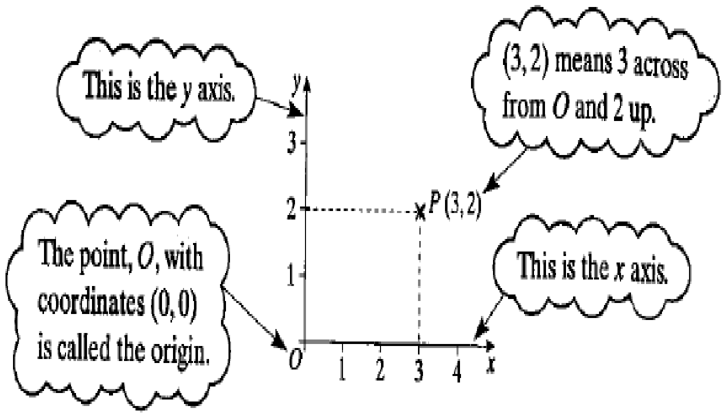
Previous Knowledge:

- They have some experience of drawing and interpreting graphs in the science class (e.g. temperature and time) and ratios (e.g. percentages, fractions, density, volume).
- Students will have experience of graphs (bar graphs, pie charts, trend graphs, histographs) in their everyday lives, such as opinion polls, weather reports, breakdown of examination results, etc.

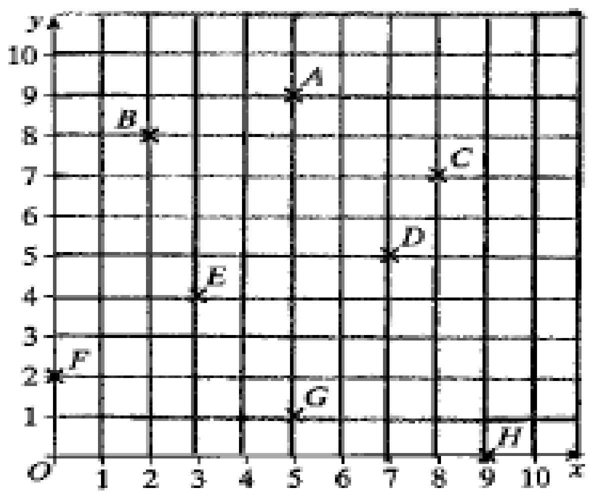
Pupil Activity

Introductory Activity:

The position of a point on a graph can be given by its **coordinates**. For example, on the graph below the position of the point P is (3, 2).



Mathematical Task 1: Work Out the Coordinates



1. Write down the coordinates of the points A to H

Teacher Guidelines

Introductory Activity:

Key student learning outcomes from this part of the lesson include:

- Interpret graphical information.
- Stating coordinate points identified on a graph.

Possible Teaching Approach

This problem needs teacher guidance and explanation when students are answering the questions. It would therefore be a good idea for the whole group to read it together and then work on it question by question, while generating discussion.

Key concepts to be explored:

- The horizontal axis is labeled the x-axis.
- The vertical axis is labeled the y-axis.
- The point (0, 0) is called the origin.
- To read a specific coordinate point 'move along the x-axis first and then up the y-axis'.

Key Teacher Questions

How many axes do we have?
What do we call each of the axes?
How do we read a particular coordinate point on the graph?

e.g. the point A is (5, 9)

Remember 'along first then up'.

B =

C =

D =

E =

F =

G =

H =

Possible Extension

Students could mark their own points on the graph to be answered by another student.

Possible Support

For those who are struggling, you could suggest using a ruler to connect the coordinates to the values on the x and y axes.

Solution

B = (2, 8)

C = (8, 7)

D = (7, 5)

E = (3, 4)

F = (0, 2)

G = (5, 1)

H = (9, 0)

Developmental Stage:

Mathematical Task 2: Drawing a Graph

- Draw a pair of axes on graph paper – label the x-axis and the y-axis.
- Use a scale of 0 to 10 on both axes.
- Plot the points **A** (2, 8), **B** (7, 8), **C** (7, 2) and **D** (2, 2).
- Join the points in alphabetical order to form a closed shape.
- What is the name of the shape?

Developmental Stage – Increasing Difficulty of Concepts/Questions:

Key student learning outcomes from this part of the lesson include:

- Drawing axes and labelling them appropriately.
- Plotting the coordinate points on a graph.
- Connecting the coordinate points to form a square.

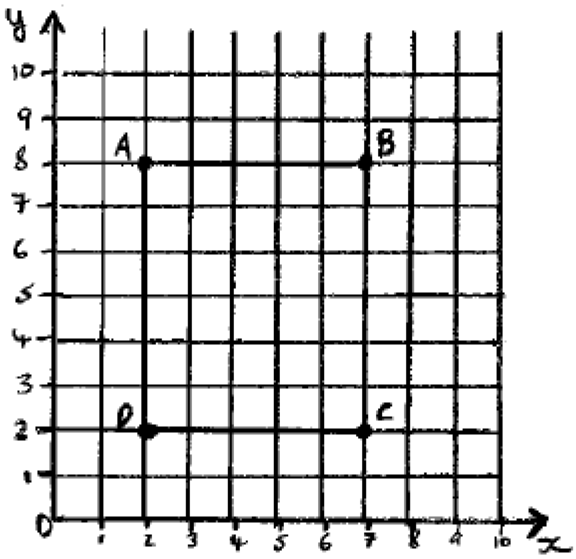
Possible Extension

You could encourage the students to look at what other shapes they could plot and accordingly what coordinates would be need to plot this shape on the graph.

Possible Support

In addition to talking more with those students who are finding the task challenging, it might be appropriate to use peers to help a student to develop their graph.

Solution



Possible Teaching Approach

To encourage learners to engage with the information you can lead this task by taking the students through it step by step to initially draw the axes and the scale being used.

Students should be able to plot the coordinate points based the previous task in the lesson.

You will need to ensure that the students have suitable graphing paper or grid paper.

Key Teacher Questions

- How many axes do we have?
- What do we call each of the axes?
- What scale are we using on each of the axes?
- How do we plot a particular coordinate point on the graph?
- What shape do we have when we connect the coordinate points?

Application of Knowledge:

1. Draw a pair of axes on graph paper – label the x-axis and the y-axis.
- Use a scale of 0 to 10 on both axes.
- Plot the points **A** (3, 7), **B** (6, 7), **C** (6, 4) and **D** (3, 4).
- Join the points in alphabetical order to form a square.

2. Draw a pair of axes on graph paper – label the x-axis and the y-axis.
- Use a scale of 0 to 6 on both axes.
- Plot the points **A** (1, 1), **B** (1, 4), **C** (4, 4).
- A fourth point, D, is needed to form a square. Write down the coordinates of D.
- Connect the four points to make a square.

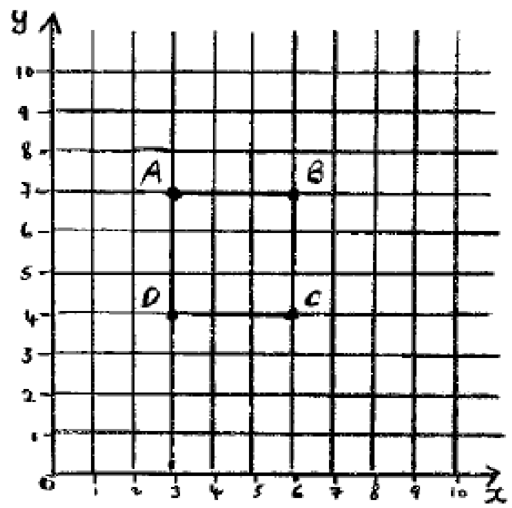
Application of Knowledge: Further experience of drawing graphs

These are further questions that students can do to develop their graphing skills and are based on the same concepts developed in Mathematical Tasks 1 and 2.

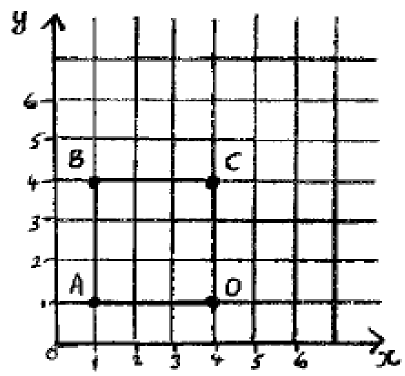
If there is not sufficient time in the lesson, these can be done as **Homework.**

Solution

1.



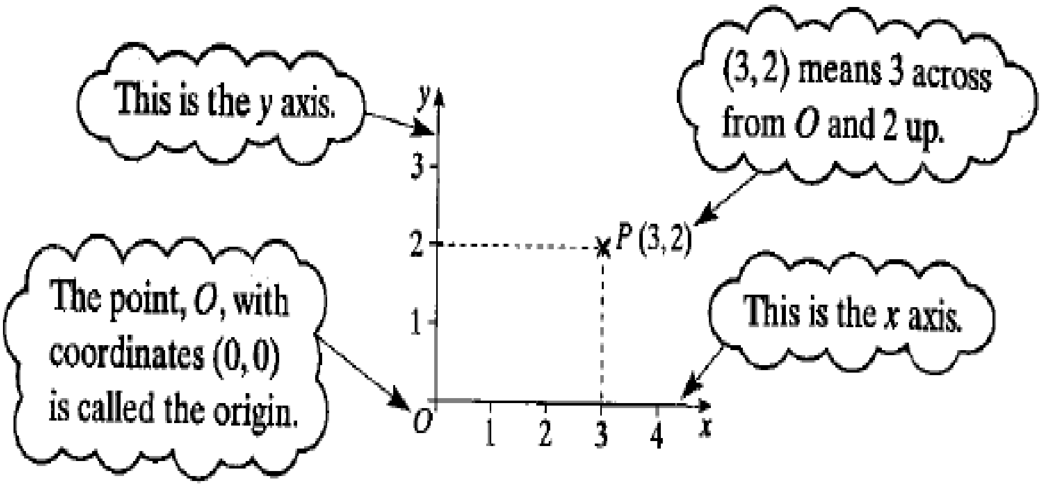
2.



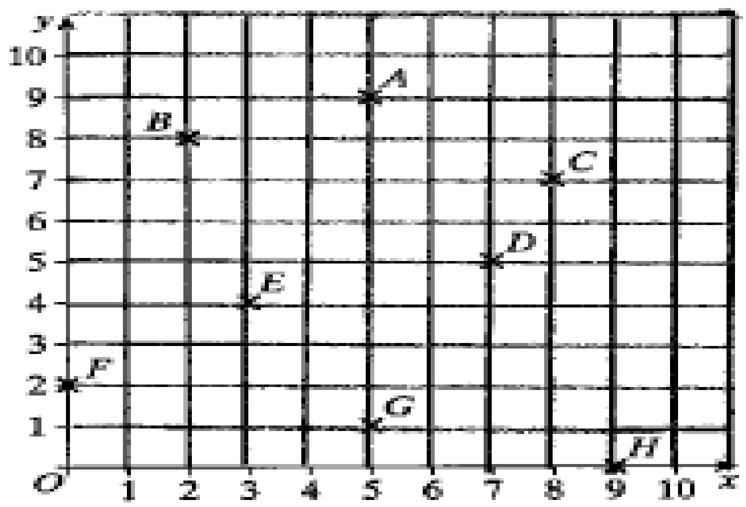
D = (4, 1)

Student Handout

The position of a point on a graph can be given by its **coordinates**. For example, on the graph below the position of the point P is (3, 2).

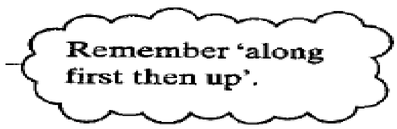


Mathematical Task 1: Work Out the Coordinates



1. Write down the coordinates of the points A to H

   For example, the point A is (5, 9)



B =

C =

D =

E =

F =

G =

H =

Mathematical Task 2: Drawing a Graph

- Draw a pair of axes on graph paper – label the x-axis and the y-axis.
- Use a scale of 0 to 10 on both axes.
- Plot the points **A** (2, 8), **B** (7, 8), **C** (7, 2) and **D** (2, 2).
- Join the points in alphabetical order to form a closed shape.
- What is the name of the shape?

Application of Knowledge

1. Draw a pair of axes on graph paper – label the x-axis and the y-axis.

- Use a scale of 0 to 10 on both axes.
- Plot the points **A** (3, 7), **B** (6, 7), **C** (6, 4) and **D** (3, 4).
- Join the points in alphabetical order to form a square.

2. Draw a pair of axes on graph paper – label the x-axis and the y-axis.

- Use a scale of 0 to 6 on both axes.
- Plot the points **A** (1, 1), **B** (1, 4), **C** (4, 4).
- A fourth point, D, is needed to form a square. Write down the coordinates of D.
- Connect the four points to make a square.

Appendix C Science Lesson 2

Enquiry Based Science Lesson 2 – Graphical representation of Speed

This first year class would have discussed how to measure speed. They would have built their own balloon rocket cars and carried out a simple motion test on it. They would have encountered measurement, quantities and basic relationships to date in first year science. They have some experience of drawing and interpreting graphs (i.e. temperature and time) and ratios (i.e. density). They have experience of *Motion* from their everyday lives such as movement at different speeds.

Class discussion and questioning on how speed can be measured.

Recap on how they planned on testing the speed of their balloon rocket cars.

Could be…
A recap on how speed is measured leading to how speed can be represented

How can speed be represented?

A class discussion on how speed can be represented.

Teacher explains they will investigate speed represented by a data table and a graph

Could be…
Students come up with ideas on how speed can be represented (i.e. on a data table, graphically, numerically)

Teacher gives students the task of generating data from their balloon rocket car.

Class generates data from their balloon rocket cars

The relationship between distance, speed and time discussed.

Relate the experience they had with measuring the speed of the balloon rocket car and interpreting the graph to other examples of graphs i.e. an object at rest, objects moving at different speeds.

Could be…
Using the cars they will create a distance versus time **data table** using the motion probe and the TI-Nspire.

Students will hand draw a graph of distance versus time from the data table

Student will interpret the distance-time graph

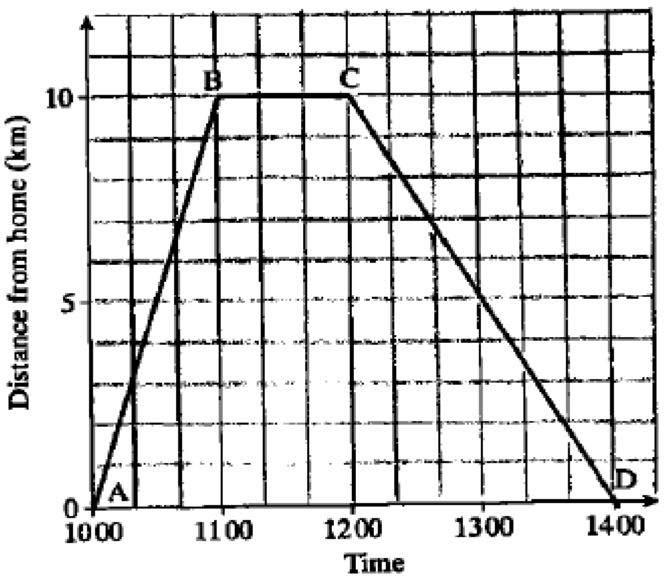
Generate from data the relationship between Distance, Speed and Time

Appendix D Maths Lesson 2

Mathematics Lesson Plan 2

Previous Knowledge:

- Students will have encountered measurement, quantities and basic relationships in their first year mathematics and science classes.
- Data and measure are key strands in the primary school mathematics curriculum.
- They have some experience of drawing and interpreting graphs in the science class (e.g. temperature and time) and ratios (e.g. percentages, fractions, density, volume).
- Students will have experience of graphs (bar graphs, pie charts, trend graphs, histographs) in their everyday lives, such as opinion polls, weather reports, breakdown of examination results, etc.
- Students have experience of *Motion* (distance/speed/time) from the previous science lesson and have real-life data collected for use in this mathematics lesson.

Pupil Activity	**Teacher Guidelines**
Introductory Activity: **Mathematical Task 1: Going for a Cycle** A travel graph is used to show the different stages of a journey. You will need to be able to interpret a travel graph. Look at this travel graph. It shows Ben going for a cycle, stopping for a rest and then returning home.  1. What time did Ben start cycling at? 2. How far does he travel between A and B? 3. How long does it take him to cycle between A and B? 4. What happens Ben between B and C?	**Introductory Activity:** Key student learning outcomes from this part of the lesson include: ➢ Interpret graphical information. ➢ Recognising positive/negative slopes. ➢ Labelling axes. ➢ Understanding which variables are plotted on the x- and y- axes. **Possible Teaching Approach** This is a problem which can be easily misread and needs teacher guidance when students are answering the questions. It would therefore be a good idea for the whole group to read it together and then work on it question by question, while generating discussion. **Key concepts to be explored:** • The horizontal axis (x-axis) shows the time of the journey. • The vertical axis (y-axis) show the distance travelled. • Ben is moving with the greatest speed between A and B. He is moving at a steady rate from A to B. • Ben is at rest (stopped) between B

5. How far does Ben travel between C and D? 6. How long does it take Ben to cycle between C and D? 7. Ben arrives back home at D. What time does Ben arrive home? 8. How far did Ben cycle altogether? **Possible Extension** Students could create their own questions to be answered based on the information represented in the graph. **Possible Support** For those who are struggling, you could suggest using a ruler to connect the co-ordinates to the values on the x and y axes. **Solution** 1. 10.00 or 10 am. 2. 10 km. 3. 1 hour. 4. He stops/is at rest. 5. 10 km. 6. 2 hours. 7. 14.00 or 2 pm 8. 20 km.	and C. • Between C and D Ben is returning home at a steady rate but more slowly (it takes him twice the time to travel the same distance). • At D Ben is back at his starting point. • Altogether Ben has cycled 20 km in 4 hours. **Key Teacher Questions** What exactly is being measured on each axis? What units (km and time) are we using? How does a graph display when a person is stopped?

Application of Knowledge:
 	
➢ Using data generated from the science lesson to draw a distance-time graph on your TI-Nspire.
  o Open the saved document on the TI-Nspire (from the science lesson).
  o Data should be presented in a Lists and Spreadsheets document.
  o Split the page and add a Data and Statistics application.
  o Label the axes.
  (see TI-Nspire handouts to refresh memory on how to do this).
 	
➢ Demonstrating key learning outcomes acquired from the previous part of the lesson.
  o Students should be able to label the axes and discuss the shape of the graph in relation to distance and time.
 	
Possible Extension
You could encourage the students to use other student's data collected in the science lesson to draw another distance-time
	Application of Knowledge: Use of data from the science lesson with the TI-Nspire
	It may be useful for the students to have the hand drawn graph from the Science lesson with them for the mathematics lesson in order to compare it to the graph generated by the TI-Nspire.
	
	Key student learning outcomes from this part of the lesson include:
	
	➢ Using data generated from the science lesson to draw a distance-time graph on the TI-NSpire.
	➢ Demonstrating key learning outcomes acquired from the previous part of the lesson.
	➢ Discussion and explanation of findings from the graph.
	
	Possible Teaching Approach
	Using the data generated from the lesson students will draw a distance-time graph

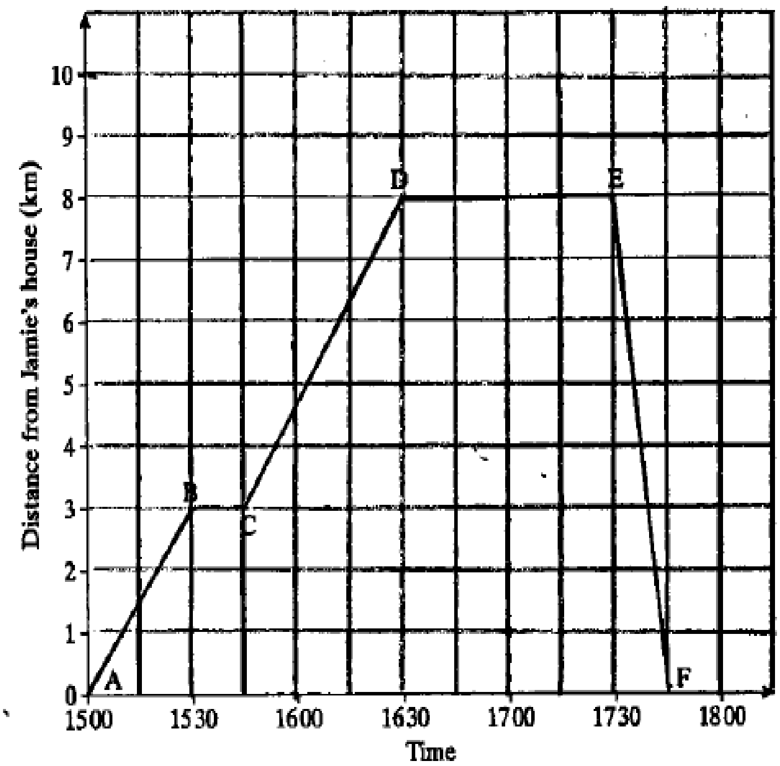
graph. Generate discussion around differences in the graphs.

Possible Support
Use peers to help students who are struggling to draw the graph.

Developmental Stage:

Mathematical Task 2: Going to the Cinema

Last Saturday Jamie started walking to the cinema at 3 pm, he stopped to talk to a friend on the way and then continued walking to the cinema. He watched the film for an hour and then he got the bus back home at 5.30 pm. The following travel graph shows his journey.



1. What time did Jamie leave home?
2. What is the scale used for the x-axis (Time)? That is, 1

from the table of data collected on motion in the science lesson (Lesson Plan 2) and stored on the TI-Nspire.

Students will compare the graph drawn in the mathematics lesson with the graph produced by the TI-Nspire.

Key Teacher Questions
Discussion will be generated around the key learning objectives outlined in each of the previous sections.

Developmental Stage – Increasing Difficulty of Concepts/Questions:

Key student learning outcomes from this part of the lesson include:

- Stating the scale/units being used.
- Selecting coordinate points from a graph.
- Straight lines correspond to motion with a constant speed.
- The slope of the line indicates the value of the speed.
- The steeper the slope, the faster the speed.
- A horizontal line shows the object at rest – indicates no movement at all (slope = 0 = speed).
- Lines with a positive slope indicate movement away from the starting point.
- Lines with a negative slope indicate movement back towards the starting point.

Possible Teaching Approach
To encourage learners to engage with the information in the travel graph you could ask a few starter questions, such as "what time of the day does James decide he wants to go into town?" and "how did he get into town?".

This problem lends itself to being tackled in pairs. Ask each group to try to answer the questions and as they are square = ?

3. What is the scale used for the y-axis (Distance)? That is, 1 square = ?
4. How long does Jamie stop to talk to his friend on his way to the cinema?
5. What time does Jamie get to the cinema at?
6. How far is the cinema from Jamie's house?
7. What time did Jamie get home from the cinema at?
8. What is the direction of the slope of the line when Jamie is walking into town?
9. Is Jamie's speed greater between C and D or between E and F? Explain how you can tell.
10. What is the direction of the slope of the line when he is returning home?

Possible Extension

You could encourage the students to look at the distance travelled and its relationship with time through comparing the time taken to walk into town and getting the bus back.

Possible Support

In addition to talking more with those students who are finding the task challenging, it might be appropriate to simplify the problem by concentrating on selecting fixed co-ordinates such as 'what time did he arrive in town?', 'what time did he leave home?', etc.

Solution

1. 15.00 or 3 pm.
2. 1 square = 15 minutes.
3. 1 square = 1 km.
4. 15 minutes.
5. 16.30 or 4.30 pm.
6. Positive slope.
7. 8 km.
8. Jamie's speed is greater between E and F. The slope of the line is steeper which is explained by the fact that he got the bus home from town.
9. 17.45 or 5.45 pm.
10. Negative slope.

working, look out for those groups who are communicating well and perhaps those who divide the task amongst themselves. You might like to ask groups who have organised their approach well to share their strategies with everyone else. The main point of this activity is for students to be immersed in the data so that they begin to use it confidently.

Key Teacher Questions

- How is time/distance represented in the graph?
- How can we pick out a particular co-ordinate point on the graph?
- Straight lines correspond to motion with a constant speed.
- What indicates the value of the speed?
- What represents Jamie not moving?
- What represents movement away from the starting point?
- What represents movement back towards the starting point?

Homework

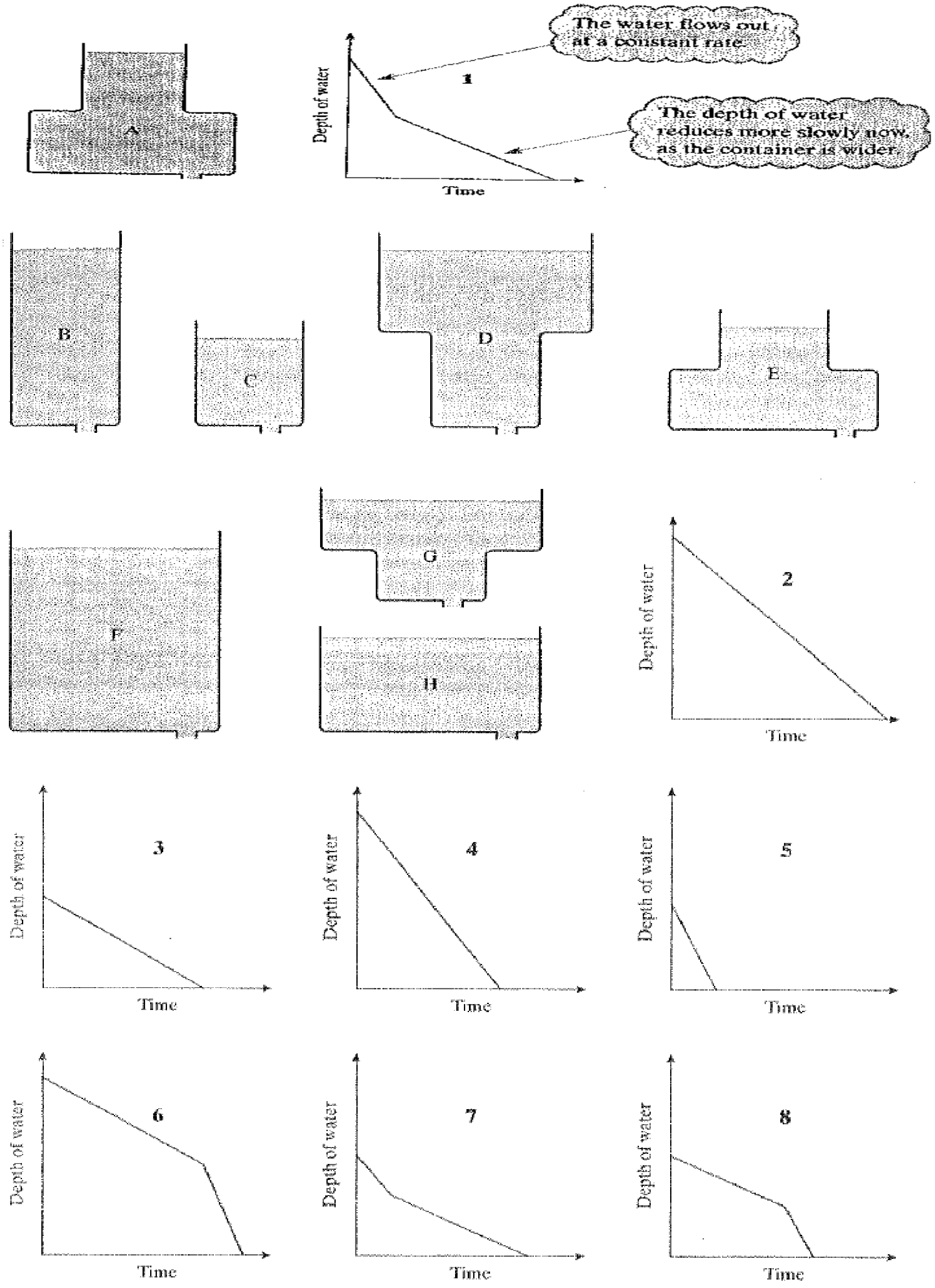
Mathematical Task 2- Going to the Cinema can be used for homework if the students do not have enough time in the lesson to start/finish it.

Further tasks are provided on a handout in order to challenge students' concepts of direction of slopes, depth of water and time. **It is at the discretion of the teacher if they would like to provide the students with these tasks.**

Mathematical Task for Homework 1

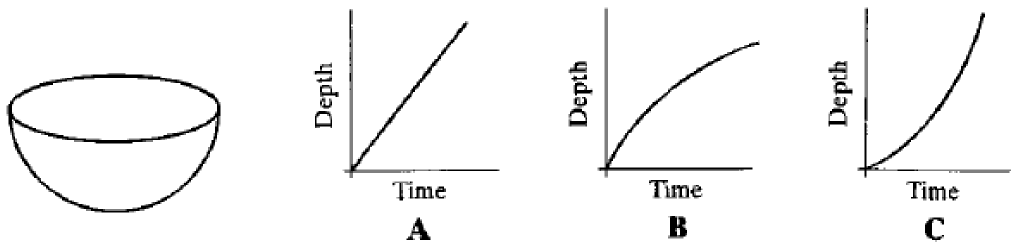
All the containers are filled with water.
There is a hole in the base of each container.
The graphs show depth of water against time.

Match each container with its graph.



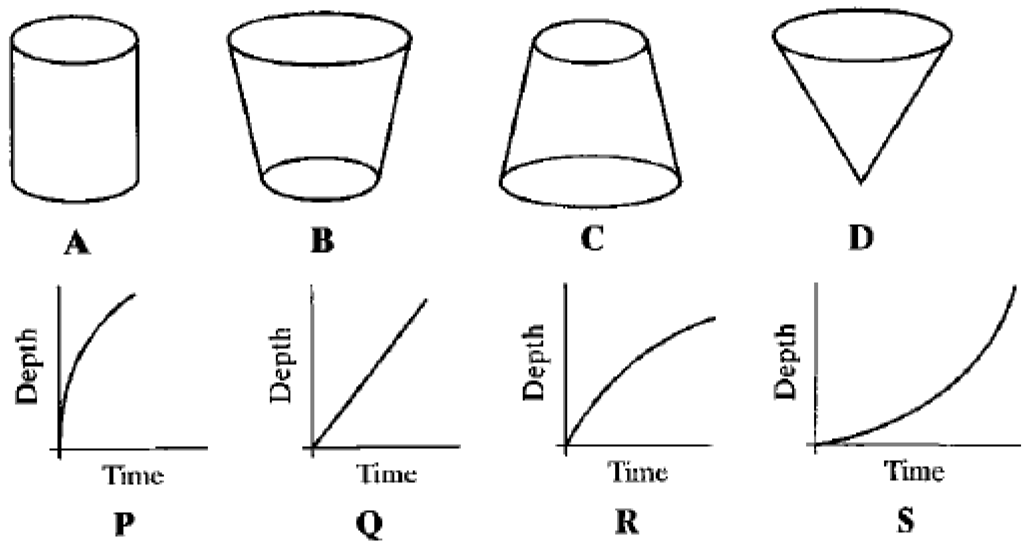
Mathematical Task for Homework 2

The diagram below shows a bowl.
It is in the shape of a hemisphere (half a sphere).
Water is poured into the bowl at a steady rate.



Say which graph, A, B, or C, best describes how the depth of water in the bowl varies over time. State why.

Water is poured at a steady rate into four different containers A, B, C and D. the graphs P, Q, R and S show how the depth of water in each container changes over time. Match the shapes to their corresponding graphs.

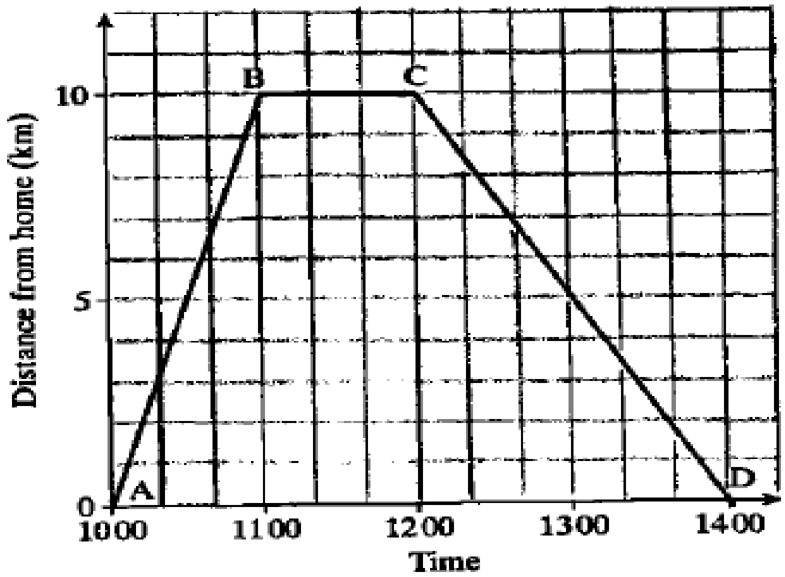


Student Handout

A travel graph is used to show the different stages of a journey. You will need to be able to interpret a travel graph.

Mathematical Task 1: Going for a Cycle

Look at this travel graph. **It shows Ben going for a cycle, stopping for a rest and then returning home.**



1. What time did Ben start cycling at?
2. How far does he travel between A and B?
3. How long does it take him to cycle between A and B?
4. What happens Ben between B and C?
5. How far does Ben travel between C and D?
6. How long does it take Ben to cycle between C and D?
7. Ben arrives back home at D. What time does Ben arrive home?
8. How far did Ben cycle altogether?

Application of Knowledge:

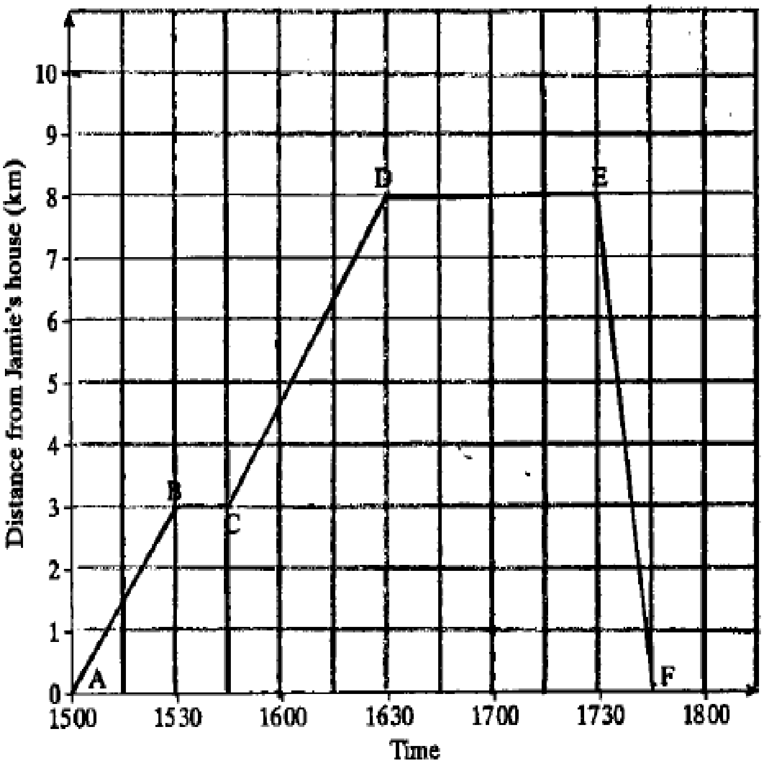
- Using data generated from the science lesson to draw a distance-time graph on your TI-Nspire.
  - Open the saved document on the TI-Nspire (from the science lesson).
  - Data should be presented in a Lists and Spreadsheets document.
  - Split the page and add a Data and Statistics application.
  - Label the axes.

  (see TI-Nspire handouts to refresh memory on how to do this).

- Demonstrating key learning outcomes acquired from the previous part of the lesson.
  - You should be able to label the axes and discuss the shape of the graph in relation to distance and time.

Mathematical Task 2: Going to the Cinema

Last Saturday Jamie started walking to the cinema at 3 pm, he stopped to talk to a friend on the way and then continued walking to the cinema. He watched the film for an hour and then he got the bus back home at 5.30 pm. The following travel graph shows his journey.



1. What time did Jamie leave home?

2. What is the scale used for the x-axis (Time)? That is, 1 square = ?

3. What is the scale used for the y-axis (Distance)? That is, 1 square = ?

4. How long does Jamie stop to talk to his friend on his way to the cinema?

5. What time does Jamie get to the cinema at?

6. How far is the cinema from Jamie's house?

7. What time did Jamie get home from the cinema at?

8. What is the direction of the slope of the line when Jamie is walking into town?

9. Is Jamie's speed greater between C and D or between E and F? Explain how you can tell.

10. What is the direction of the slope of the line when he is returning home?

Appendix E Science Lesson 3

Enquiry Based Science Lesson 3 – Mapping the motion of speed

This first year class would have encountered measurement, quantities and basic relationships in their first year mathematics and science classes. They have experience of drawing and interpreting graphs (e.g. distance and time) and ratio (e.g. speed). Students will have experience of graphs in their everyday lives. In previous mathematics lessons students examined distance versus time graphs and they would have answered questions in relation to the direction of the motion and the slope.

Class have experience of drawing distance versus time graph.

Teacher asks questions on the motion of the graphs they have drawn and discussed in previous mathematics and science lessons

Could be…
Act out the motion of an object speeding up, slowing down, and not moving using their TI-Nspire and motion probe

Distance versus time graphs motion prediction

Teacher sets the task of predicting the motion of several graphs and asks the students to find out if their prediction was correct using the TI-Nspire and motion probe

Could be…
Be able to predict the motion of several distance-time graphs.
Students will act out that a line with a positive slope indicating movement away from the starting point and lines with a negative slope indicating movement back towards the starting point.

Interpret a travel graph showing different stages of a journey

The relationship between distance, speed and time discussed and calculated.

Could be…

On the TI-Nspire they will have both the graph and list and spreadsheets page to look at and work from.

Relate the experience they had with measuring the speed of their own car and interpreting the graph to other examples of graph i.e. an object at rest, objects moving at different speeds.

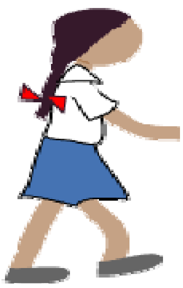
Develop the relationship between Distance, Speed and Time by predicting and acting out the motion of distance-time graphs data

Appendix F Maths Lesson 3

Mathematics Lesson Plan 3

Previous Knowledge:

- Students will have encountered measurement, quantities and basic relationships in their first year mathematics and science classes.
- Data and measure are key strands in the primary school mathematics curriculum.
- They have some experience of drawing and interpreting graphs in the science class (e.g. distance and time) and ratios (e.g. speed). Students will have experience of graphs (bar graphs, pie charts, trend graphs, histographs) in their everyday lives, such as opinion polls, weather reports, breakdown of examination results, etc.
- Students have experience of *Motion* (distance/speed/time) and Travel Graphs from previous science and mathematics lessons.

Pupil Activity	Teacher Guidelines
Introductory Activity: **Mathematical Task 1: Practical Run** Sarah was practicing a long distance run she was going to do next week. This run would take her 1 hour to complete.   • In the first 10 minutes she **sprinted** 2 km. • In the second 10 minutes she **ran** half the distance that she had sprinted. • In the third 10 minutes she **jogged** just half as far as she had ran. • In the fourth 10 minutes she **walked** and only managed to cover half the distance as she had jogged. • In the fifth 10 minutes she was **walking slower** and only managed to cover half the distance that she had walked in the previous 10 minutes. • In the final 10 minutes she **sprinted** the last 125 m. **How far was the race to be and how long did Sarah take doing it?**	**Introductory Activity:** Key student learning outcomes from this part of the lesson include: ➢ Speed is a measure of how fast an object is travelling. ➢ The speed of an object will determine how far it travels. ➢ Generate the formula: **Average speed** = $\frac{\text{total distance}}{\text{total time.}}$ **Possible Teaching Approach** This is a problem which can be easily misread. It would therefore be a good idea for the whole group to read it together and then put it into their own words. These can then be compared and a discussion started on the best place to begin doing the problem itself. After this students could work on the problem in pairs so that they are able to talk through their ideas with a partner.

Possible Extension
Learners could change the problem to ask what the figures would be if the race was exactly 2 km long.

Possible Support
For those who are struggling, you could suggest starting at the end of the problem and working backwards.

Solution (students can use the Lists and Spreadsheets application for this task)

Minutes	Minutes so far	Distance in metres	Distance so far in metres
10	10	2 000.00	2 000.00
10	20	1 000.00	3 000.00
10	30	500.00	3 500.00
10	40	250.00	3 750.00
10	50	125.00	3 875.00
10	60	125.00	4000.00
Total	**60**		**4000.00**

Students need to use the lists and spreadsheets function of their TI-Nspire in order to make a table of their findings. You need to set up a table and demonstrate how to fill in the information as they are working through the problem.

At the end of this part of the lesson the group could be brought together again to discuss their findings and how they reached them.

Key Teacher Questions
What exact measurement do we know from the question?
How might you use a table to organise the information?
What distance was the race?
How long did it take Sarah to complete it?

Subsequent Classroom Discussion
Discussion based on the different speeds Sarah had (e.g. sprinting, running, jogging and walking). **How do we calculate her average speed?** Allow students to make suggestions given the information they already have (i.e. they have information on the distance she travelled and how long it took her).

Generate formula:

$$\text{average speed} = \frac{\text{total distance}}{\text{total time}}$$

Sarah's average speed = 4 km/hr

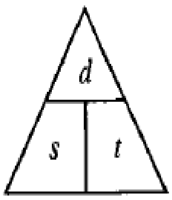
Developmental Stage:

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

or

$$s = \frac{d}{t}$$

You might find this 'cover-up' triangle helps:



Mathematical Task 2: [Who has the fastest average speed?]

Timmy, Tammy and Tommy all have tummy ache!

They all set off separately to visit their doctor, leaving their homes at exactly the same time.

Timmy cycles the 8 km to the doctors and it takes him 24 minutes to get there.

Tammy walks the 1.2 km and arrives there after 18 minutes.

Tommy drives the 16.5 km to the doctors and arrives there after 22 minutes.

What are their average speeds (in km/hr) and put them in order?

Who gets there first?

Does average speed make a difference to getting to the doctor's?

(students can use the calculator application in their TI-Nspire for this task).

Developmental Stage – Further Calculation of Average Speed:

Key student learning outcomes from this part of the lesson include:

- Further development of the concept of average speed and its relationship with distance and time.
- Developing students' knowledge of the use of units i.e. km/hr.

Possible Teaching Approach

The teacher should generate discussion around calculating average speed and help the students with the task. Perhaps demonstrate calculating Timmy's average speed while questioning the students in relation to the steps being undertaken.

It will be necessary to draw students attention to the importance of the units (km/hr) being used and the implications for the calculations being undertaken.

e.g. Timmy' Average Speed

average speed $= \dfrac{\textbf{total distance (km)}}{\textbf{total time (hour)}}$

We need Timmy's speed in km/hr. So we need to change 24 minutes to hours.

$$24 \text{ minutes} = \frac{24}{60} = 0.4 \text{ hours}$$

So,

Timmy's average speed $= \dfrac{8}{0.4}$

$= 20$ ***km/hr***

By engaging the students in looking at their solutions (average speed for each

Possible Extension
Provide students with the distance and average speed and get them to calculate how long it took the person to get to the doctors.

Possible Support
In addition to talking more with those students who are finding the task challenging, it might be appropriate to simplify the problem by changing the units and using easier numbers for calculation.

Solution

Timmy cycles 20 km/hr;

Tammy walks 4 km/hr;

Tommy drives 45 km/hr.

The order therefore is Tommy, Timmy, and Tammy.

Tammy gets there first but has the slowest average speed. She lives nearest the doctors and therefore distance is important. Tommy arrives next even though he has further to travel then Timmy but he is travelling more than 2 times his average speed.

person) and comparing with who actually arrived at the doctor's first should develop their understanding further of the relationship between distance-speed-time.

Key Teacher Questions
What do we need to know in order to calculate average speed?
Who had the fastest average speed?
Does average speed make a difference for getting to the doctors first?

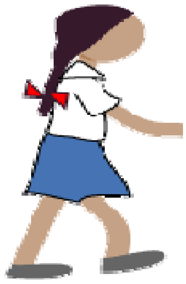
Homework Task:

Use the 'Possible Extension' as a homework task for the students.

Student Handout

Mathematical Task 1: Practical Run

Sarah was practicing a long distance run she was going to do next week. This run would take her 1 hour to complete.



- In the first 10 minutes she **sprinted** 2 km.
- In the second 10 minutes she **ran** half the distance that she had sprinted.
- In the third 10 minutes she **jogged** just half as far as she had ran.
- In the fourth 10 minutes she **walked** and only managed to cover half the distance as she had jogged.
- In the fifth 10 minutes she was **walking slower** and only managed to cover half the distance that she had walked in the previous 10 minutes.
- In the final 10 minutes she **sprinted** the last 125 m.

How far was the race to be and how long did Sarah take doing it?

Use the Lists and Spreadsheets application in your TI-Nspire for this task and generate a table of data.

Minutes	**Minutes so far**	**Distance in metres**	**Distance so far in metres**
10			
10			
10			
10			
10			
10			
Total			

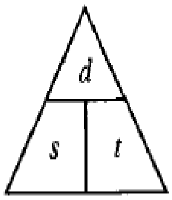
Developmental Stage:

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

or

$$s = \frac{d}{t}$$

You might find this 'cover-up' triangle helps:



Mathematical Task 2: Who has the fastest average speed?

Timmy, Tammy and Tommy all have tummy ache!

They all set off separately to visit their doctor, leaving their homes at exactly the same time.

Timmy cycles the 8 km to the doctors and it takes him 24 minutes to get there.

Tammy walks the 1.2 km and arrives there after 18 minutes.

Tommy drives the 16.5 km to the doctors and arrives there after 22 minutes.

What are their average speeds (in km/hr) and put them in order?

Who gets there first?

Does average speed make a difference to getting to the doctor's?

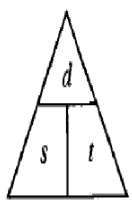
You can use the calculator application in your TI-Nspire for this task.

Appendix G Maths Lesson 4

Mathematics Lesson Plan 4

Previous Knowledge:

- Students will have encountered measurement, quantities and basic relationships in their first year mathematics and science classes.
- Data and measure are key strands in the primary school mathematics curriculum.
- They have experience of drawing and interpreting graphs in the previous science and mathematics lessons.
- Students have calculated the average speed of objects in the previous mathematics lesson.

<table>
<tr><th>Pupil Activity</th><th>Teacher Guidelines</th></tr>
<tr>
<td>
<u>Introductory Activity:</u>
Mathematical Task 1: <u>Calculating the Average Speed of their Balloon Rocket Cars</u>
$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$
or
$$s = \frac{d}{t}$$
You might find this 'cover-up' triangle helps:


Using data generated from the science lesson 1 calculate the average speed of their balloon rocket cars.

Open the saved document on the TI-Nspire (from science lesson 2).
Data should be presented in a Lists and Spreadsheets document.

</td>
<td>
<u>Introductory Activity:</u>
Key student learning outcomes from this part of the lesson include:

Using data generated from the science lesson to calculate average speed.
Demonstrating key learning outcomes acquired from the previous science and mathematics lessons.

Speed is a measure of how fast an object is travelling.
The speed of an object will determine how far it travels.
Formula:
$$\text{Average speed} = \frac{\text{total distance}}{\text{total time.}}$$

Appreciate the application of mathematics in science and real life applications.

Possible Teaching Approach
Using the data generated from the lesson students will calculate the average speed of their balloon rocket cars from the table of data collected on motion in the science lesson and stored on the TI-Nspire.
Students will compare average speeds calculated by the various groups (students will have worked on this task in groups in the science lesson so students will be have
</td>
</tr>
</table>

- Demonstrating key learning outcomes acquired from the previous mathematics lesson.
  - Calculate the average speed of their balloon rocket car by calculating total distance and total time.
- Discussion and explanation of findings generated from students' calculations.

Possible Extension
Learners could calculate the average speed of other student's balloon rocket cars and compare findings.

Possible Support
For those who are struggling, you could organise the task into manageable steps and targets such as calculating the total distance first, than getting them to calculate the total time and accordingly work out the average speed.

Solution
Will be dependent on the data gathered in the science lesson.

the same data as others) in the mathematics lesson.

Key Teacher Questions
Discussion will be generated around the key learning objectives outlined.
Why is there a difference in average speeds between the balloon rocket cars?

Application of Knowledge:

Mathematical Task 2: Lengthy Journeys

Above is a map of Ireland showing the major cities and towns around the country. We are going to concentrate on some car journeys between **Dublin**, **Cork**, **Limerick**, **Waterford** and **Thurles**.

Application of Knowledge – Further Experience of Distance/Time/Speed:

Key student learning outcomes from this part of the lesson include:

- Introduce students to handling more complicated data.
- Provide them with the opportunity to calculate distance, time and average speed based on their own selection of journeys.
- Reinforce previous learning.

Possible Teaching Approach
It would be nice to have a map of Ireland to start off this problem (or for pairs of students to have an atlas or road map) and ask students to locate the cities/towns in question. You can then draw attention to the problem. To encourage learners to engage with the information in the table, you could ask a few starter questions, such as "how far is the journey from Cork

Please open the document in your TI-Nspire (which contains the following table). We could make some journeys between these locations and so here is a table giving us some information about distances and time:

			Kilometres (km)	Hours	Minutes
Cork	to	**Dublin**	255	3	05
Cork	to	**Limerick**	101	1	32
Cork	to	**Waterford**	121	1	50
Cork	to	**Thurles**	118	1	24
Waterford	to	**Dublin**	166	2	16
Waterford	to	**Limerick**	128	2	03
Waterford	to	**Thurles**	100	1	29
Dublin	to	**Limerick**	195	2	42
Dublin	to	**Thurles**	145	1	53
Thurles	to	**Limerick**	75	1	15

Open a new calculator page on your TI-Nspire. Calculate the average speed for each of these journeys.

These numbers show us direct routes. But now, suppose we go on journeys involving 3 or 4 locations. For example, we could go from Cork to Thurles but go through Limerick on the way.

What other journeys involving 3 or 4 locations can you find?

When you have some of these journeys, answer the following questions:

1. What is the total distance of your journey in Kilometres?
2. How many minutes long is your journey?
3. How much longer (in terms of time) is the journey when passing through another city/town along the way compared with the direct journey between the starting city and final destination?
4. Calculate the **average speed** for each of the journeys.

Possible Extension

You could encourage the students to create their own questions based on the information given.

to Dublin?" and "what journeys could you make in under 3 hours?".

This problem lends itself to being tackled in groups, for example of three or four students. Ask each group to try to answer the questions and as they are working, look out for those groups who are communicating well and perhaps those who divide the task amongst themselves. You might like to ask groups who have organised their approach well to share their strategies with everyone else. The main point of this activity is for students to be immersed in the data so that they begin to use it confidently.

You might like to have a whole class discussion about the ambiguity of "long" in this context. Does it mean distance-wise or time-wise? Does it matter?

Key Teacher Questions

What other journeys could you make, for example, starting at Cork and ending in Dublin?

How are you going to keep track of which routes you have found?

What pieces of information do you think would be good to find in order to work out the total distance and total time taken?

What would you like to look at first in trying to get an answer?

Homework Task:

This task can be continued for homework if there is not sufficient time in the lesson or new routes can be provided for the students to work on for homework.

Possible Support

In addition to talking more with those students who are finding the task challenging, it might be appropriate to simplify the problem by fixing the starting and finishing cities/towns.

Solution

			Average Speed
Cork	to	**Dublin**	82.7 km/hr
Cork	to	**Limerick**	65.9 km/hr
Cork	to	**Waterford**	66 km/hr
Cork	to	**Thurles**	84.3 km/hr
Waterford	to	**Dublin**	75.5 km/hr
Waterford	to	**Limerick**	62.4 km/hr
Waterford	to	**Thurles**	67.4 km/hr
Dublin	to	**Limerick**	72.2 km/hr
Dublin	to	**Thurles**	77 km/hr
Thurles	to	**Limerick**	60 km/hr

The other solutions will be dependent on the routes chosen.

Student Handout

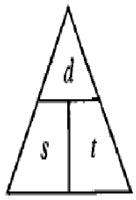
Mathematical Task 1: Calculating the Average Speed of your Balloon Rocket Cars

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

or

$$s = \frac{d}{t}$$

You might find this 'cover-up' triangle helps:



- Using data generated from the science lesson 2 calculate the average speed of their balloon rocket cars.
  - Open the saved document on the TI-Nspire (from science lesson 2).
  - Data should be presented in a Lists and Spreadsheets document.
- Demonstrating key learning outcomes acquired from the previous mathematics lesson.
  - Calculate the average speed of your balloon rocket car by calculating the total distance and total time.
- Discussion and explanation of findings generated from your calculations.

Application of Knowledge:

Mathematical Task 2: Lengthy Journeys

Above is a map of Ireland showing the major cities and towns around the country. We are going to concentrate on some car journeys between **Dublin**, **Cork**, **Limerick**, **Waterford** and **Thurles**.

Please open the document in your TI-Nspire (which contains the following table). We could make some journeys between these locations and so here is a table giving us some information about distances and time:

			Kilometres (km)	**Hours**	**Minutes**
Cork	to	**Dublin**	255	3	05
Cork	to	**Limerick**	101	1	32
Cork	to	**Waterford**	121	1	50
Cork	to	**Thurles**	118	1	24
Waterford	to	**Dublin**	166	2	16
Waterford	to	**Limerick**	128	2	03
Waterford	to	**Thurles**	100	1	29
Dublin	to	**Limerick**	195	2	42
Dublin	to	**Thurles**	145	1	53
Thurles	to	**Limerick**	75	1	15

Open a new calculator page on your TI-Nspire. Calculate the average speed for each of these journeys.

These numbers show us direct routes. But now, suppose we go on journeys involving 3 or 4 locations. For example, we could go from Cork to Thurles but go through Limerick on the way.

What other journeys involving 3 or 4 locations can you find?

When you have some of these journeys, answer the following questions:

1. What is the total distance of your journey in Kilometres?
2. How many minutes long is your journey?
3. How much longer (in terms of time) is the journey when passing through another city/town along the way compared with the direct journey between the starting city and final destination?
4. Calculate the **average speed** for each of the journeys.