Data in the digital age: Charting the way for multimedia learning

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An excellent example of how the use of digital technologies can enhance the teaching of data collection, representation, analysis and evaluation in order to solve a real problem.

Introduction

Information and communication technology (ICT) is an integral aspect of the current *Australian Curriculum: Mathematics*. The language, strategies and resources required in mathematics education today can be very different to the mathematics lessons experienced by current teachers when they themselves were at school (Sousa, 2015). Learning opportunities need to capture students' attention, provide relevant experiences, ensure they are motivating, incorporate the effective use of technology and teach students for their future (Prensky, 2010). This article provides an example of how to use digital technologies to teach data and real-world problem solving in a Year 2 classroom. Digital technologies can assist students to develop ICT capabilities as they "learn to use ICT effectively" and "investigate, create and communicate mathematical ideas and concepts" (ACARA, 2017). Achieving effective use of digital technology in a contemporary mathematics classroom, can be challenging for teachers who may be 'digital immigrants', as they strive to incorporate technology authentically for their 'digital native' students (Prensky, 2010).

Traditional teaching of data

Traditional data lessons for Year 2 students use concrete materials to collect and represent data such as: asking students to line up lunch boxes, class column graphs of hair or eye colour, and tallies of favourite fruits. The class then compares whether column graphs or tallies represent the raw data most effectively. The emphasis is on creating graphs with limited focus on using the results for any sort of decision making. Donaldson, Field, Harries, Tope and Taylor (2012) state that this overemphasis on collection and representation of data, with little time spent planning and interpreting data for a purpose, can result in students being unmotivated in this strand of mathematics. Students need to learn how to develop critical and creative thinking to identify, explore and organise their information and ideas (ACARA, 2017). Therefore, traditional data lessons may not be meeting critical and creative reasoning; additionally exploration and organisation of information may be absent.

Contemporary teaching of data

The task

Students were organised into heterogeneous groups of 4–6 students and were given the task;

> You need to deliver a large package to the school, but you don't want to disrupt the traffic flow around the school. Find the best time of day for the delivery of your package to occur.

This task was developed using the technological pedagogical content knowledge (TPACK) framework (Guerrero, 2010) to ensure that technology was integrated effectively to provide students with a rich learning experience. TPACK combines content knowledge (what students need to learn), pedagogical content knowledge (how students learn best and what possible misunderstandings may arise) and technological knowledge (what technologies are best suited to the content) to build a sophisticated understanding and application of mathematical skills using students' prior knowledge or developing new understandings in students (Koehler & Mishra, 2009).

Technological considerations

Previously students had experienced graphing using MSWord and Excel in technology lessons so, after discussion, it was decided that Excel would be used as the students felt it was easier to use for graphing than MSWord. The ease with which students can manipulate and reorganise data using Excel is beyond what is achievable without the use of this technology. However, teachers need to be confident in their understanding of Excel, as spreadsheets and graphs can be designed in many ways, depending on purpose. For teachers who are less confident the use of the Excel Import Wizard allows easy access to assistance if needed. Once a file or data set is selected, Import Wizard provides step by step guidance to create different graphical representations of data, by selecting the 'Insert' Tab then 'Charts' on the ribbon at the top of the screen.

Content knowledge needed

- Gather data relevant to the question (ACMSP048)
- Collect, check and classify data (ACMSP049)
- Create displays of data using lists, table and picture graphs and interpret them (ACMSP050)

Pedagogical content knowledge

Teachers need to have a clear understanding of what data is before they can plan effective lessons or units of work. Donaldson, et al., (2012) state that teachers emphasise the collection and representation of data, rather than ensuring students have a clear understanding of the type of data needed, the purpose of its collection and how the results will be used. This task was designed as a project with students being active problem solvers in a real-world situation. The goal was for students to discover that mathematics is not an independent area of study, but a means to explain patterns and relationships in the real-world (Stephens, Montgomery & Waters, 1997). Students were also given opportunities to formulate their own questions and directions, and investigate to build meaning, understanding and knowledge (Towers, 2010).

The learning activity

After being given the task, students were given ten minutes in their groups to brainstorm what the activity was asking them to do and the possible ways they could gain the information needed. A speaker from each group presented the group's ideas to the whole class. All groups wanted to find the quietest time of day and agreed that they needed to count the number of cars that passed in front of the school gates at different times of the day. The teacher intervened at this point to explain this process is called data collection and the class and teacher worked to link students' prior knowledge of data collection and methods used to the current task. The teacher then presented students with the instruments each group had access to:

- An iPad
- A laptop computer
- A blank tally sheet.

Students were again given ten minutes to discuss how they would use these tools. Time was again given for group sharing; a class decision was made to use the iPads to video the traffic that passed the school, for 10 minutes, at three different times during the school day. The class stated that from their experience, traffic could not be tallied accurately as the school is on a busy street. Videoing the traffic would reduce the recording error, as the video could be replayed or slowed down to accurately tally the number of cars observed. Two groups also suggested that videoing should be done at all three school gates over five days, as some days are busier due to food and supply deliveries, visitors, contract workers and so on. This discussion was rich and demonstrated students were making links between their own experiences of the school and the task. This thinking is an example of what Sparrow (2004) refers to as maths noticing; where students make sense of situations and apply them to mathematical contexts.

Recording the data

Once all groups had completed their video recordings, data collation began. Groups were asked to discuss how they could use their videos and the remaining instruments to solve the task with which they were initially presented. All groups wanted to tally the type and number of vehicles on the tally sheet as they replayed their group's videos. A brief discussion was held as to whether tallying the type of vehicles was relevant to the task. Being aware of teachable moments (Guerrero, 2010) was vital to ensure students remained focussed. The class realised that the type of vehicle was irrelevant; the time of day and number of vehicles passing needed to be the focus of tallying and graphing.

All groups decided to use the tally sheet to record data and rechecked their recording by replaying their videos. The teacher demonstrated the use of Excel from labelling columns, through to graph creation; groups then used Excel to record their data. Groups were given time and encouraged to experiment with the type of graphs they could create, with the teacher acting as a critical friend answering questions or prompting groups as necessary. Examples of graphs created by groups can be seen in Figures 1 and 2.

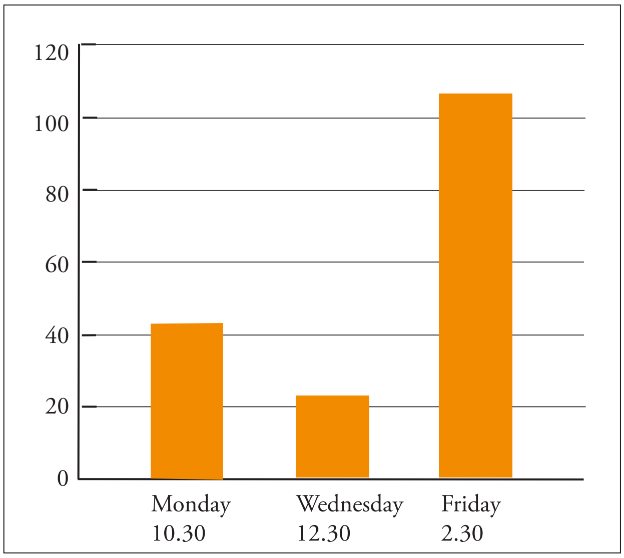
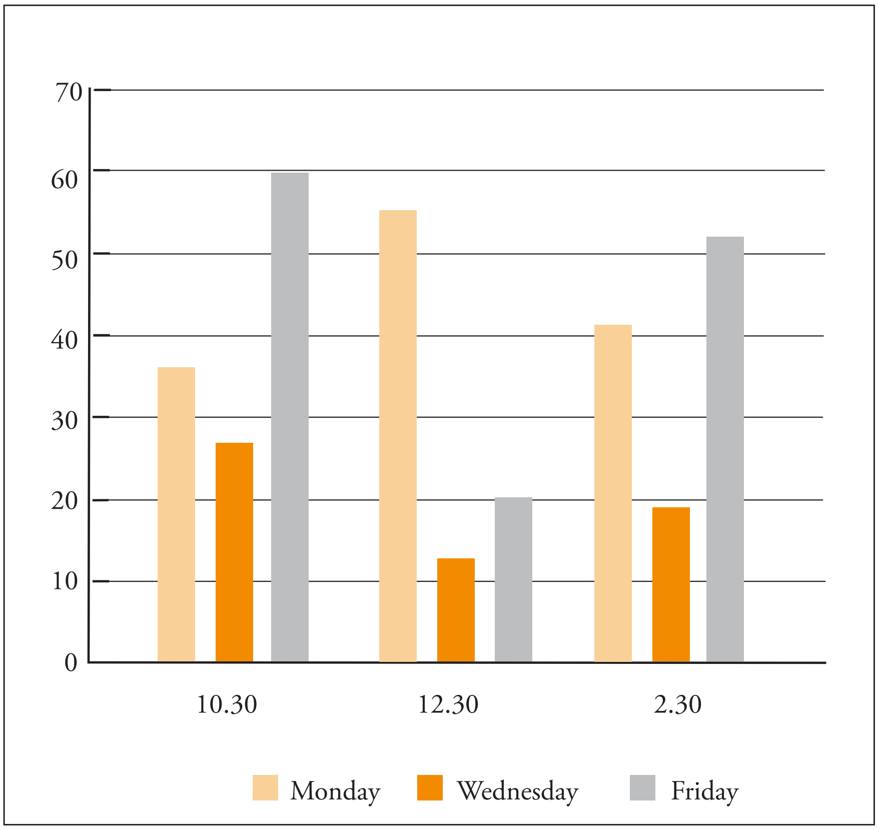


Figure 1: Limited use of Excel. Students have not understood that two variables were involved; time of day and day of the week.

Figure 2: Outstanding use of Excel for Year 2. Time of day and day of the week are used simultaneously for effective comparison of data. (Below)



Students then wrote a short report on MS Word to explain the best time of day to deliver a package to reduce traffic disruption around the school; an example of a group that demonstrated their interpretation of data to explore the scenario to a more complex level can be seen in Figure 3.

As each group presented their findings, the teacher and class provided immediate feedback on the effectiveness of the graph chosen to convey findings, and whether their understanding was reflected in the group's answer to the scenario. Feedback was a vital step in the teaching and learning process for students to practice their new skills, improve their understanding and transfer and generalise new knowledge accurately (Sousa, 2015).

Implications for student-centred learning

The group structure and task design resulted in high student engagement and absence of behavioural issues. Groups were heterogeneous so students who were challenged by mathematics could discuss and listen to the ideas of peers who are competent in mathematics, this was consistent with the work of Boaler (2009). Additionally, the small group size resulted in more students asking for clarification from their group members or teacher. Students who rarely shared their ideas or asked questions in a whole class setting, were increasingly noted to be discussing their ideas confidently with their group.

Our data showed us 2 things about delivering a package to school without disrupting traffic too much

1. The best time of the day is 12:30 any day.
2. The best day to deliver is Wednesday.

So we'll deliver our package at 12:30 on Wednesday. This is because on Wednesday not much happens at school. On Monday we have trucks for the canteen because the ice blocks run out. On Friday lots of classes have social groups so lots of parents turn up. We need to look at traffic on Tuesday or Thursday because they might be better days.

Figure 3: Example of complex interpretation of data (Figure 2). Real-world problem solving and forward thinking is evident.

The task design engaged students as they needed to solve a real-world problem. Student engagement and a teacher's ability to facilitate effective investigation with their students are suggested by McDonough and Clarke (2003) as vital for improving student growth and achievement in mathematics. The following are some suggestions by the students:

- I'm going to tell my mum to park at William St. because there's hardly any cars on that street.
- We should set up a tripod at each gate and record the traffic all day over a whole week to get a better traffic report.
- We should send our information to the council and maybe they will put in extra pedestrian crossings.
- I wish we could find out which schools in Australia have the most traffic going past.
- I wish we could find out which cities in Australia have the most traffic.

Student engagement and their intrinsic motivation to learn and apply their understanding beyond the classroom can be clearly seen in their creative thinking and reasoning. In this manner, the task can also be described as using transformative pedagogy; where students are actively engaged in their own learning, they saw the relationship between mathematics and their world and they viewed mathematics as relevant and significant (Sullivan, 2011).

In response to student interest, the Live Traffic NSW website (https://www.livetraffic.com/desktop.html) was demonstrated to the class which created great interest. Several students accessed this website during free time over the following weeks. Five students continued to use this website at home, and shared interesting information in class discussions for example, "Last night the busiest road in Sydney was Pennant Hills Road and in Newcastle it was Newcastle Road at Jesmond". Three students continued to use Excel to make their own graphs about what the houses in their street were made of, whether cats, dogs or rabbits were the favourite pet of students in their ballet class and the favourite book of all children in Year 2. The student who undertook this last study told the class it was too hard to finish because everyone had chosen a different book and she could not get around to ask everyone. Perhaps this could lead to future lessons based on another teachable moment to review the difference in discrete and continuous data!

Evaluating the level of technological integration

The Levels of Technology Implementation (LoTi) Framework was used to evaluate the effectiveness of technological integration. This framework focuses on how technology is used to promote higher order thinking, student engagement and effective assessment practices (Moersch, 1995). There are seven levels in the framework:

0. **Non-use:** Digital technology is absent or does not support purposeful learning.
1. **Awareness:** Teacher directed learning where digital technology is non-existent or used solely by the teacher to enhance visual presentations and students are engaged in lower-order thinking.
2. **Exploration:** Digital technology is used for extension, enrichment activities, information gathering or student presentations and students are engaged in lower-order thinking.
3. **Infusion:** digital technology used by students for teacher-directed tasks that emphasise higher levels of thinking and cognitive processing.
4. **Integration:**
    - **Mechanical:** Digital technology used to motivate and drive student-directed questioning. Students are engaged in real-world issues and problem-solving however the teacher may experience discipline issues in the classroom because of inadequate school structures or lack of teacher knowledge.
    - **Routine:** Digital technology used to motivate and drive student-directed questioning. Students are fully engaged in real-world issues and problem-solving and the teacher is confident to implement an inquiry-based teaching model.
5. **Expansion:** Digital technology used to motivate and drive student-directed questioning. Student collaboration is extended outside the classroom

for authentic problem solving and students demonstrate an in-depth understanding of the content and skills required.

6. **Refinement:** Digital technology is deeply embedded and beyond conventional strategies. Student collaboration and issue resolution is the norm and instruction is entirely learner-centred.

Contemporary pedagogy has changed rapidly from teacher-directed lessons to learning partnerships between teachers and students, which places a strong emphasis on inquiry, collaboration and adaptive reasoning (Hattie, Fisher, Frey, Gojak, Moore & Mellman, 2016). Digital technologies empower students and assist them to gain greater meaning, transfer their knowledge, make connections and apply their knowledge and skills to new situations. Additionally, digital technologies allow teachers and students to explore difficult concepts and enhance learning opportunities which add interest for students (Prensky, 2010). Key concepts in mathematics can be taught effectively using digital technologies such as interactive white boards (IWB), iPads, spreadsheets and specific software programs.

This task was evaluated at Level 4–Integration (Routine), as students engaged in real-world issues using digital tools. A strong emphasis was placed on student-centred learning and students were given opportunities to plan and test their own ideas. The use of Excel provided higher-order digital processing. Feedback in the form of peer and teacher review also encouraged higher-order thinking as students were required to explain and justify the choice of graph they used and how they interpreted the data to support their report. The teacher had an in-depth understanding of the learning intention and ability to use technology (Moersch, 1995).

Conclusion

The current *Australian Curriculum: Mathematics* places a strong emphasis on students being able to use ICT effectively to investigate, create and communicate mathematical ideas and concepts. Using digital technologies authentically assists students to develop their ICT capabilities. Contemporary mathematics classrooms can be effective only if teachers have a clear understanding of the content they need to teach, the best pedagogy to facilitate this learning and then identify the technology needed to enhance student learning. This data task was effective in developing students' understanding of how and why data is collected, but more importantly how it can be used to solve a problem. Students also developed their ability to question mathematically and demonstrated an intrinsic motivation to learn outside the classroom. This task encourages students to be life-long learners which is surely the goal for all contemporary classroom teachers.

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