Middle Years Students Influencing Local Policy

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Middle Years students often do not see mathematics as useful. Authentic and real mathematics tasks and artefacts are frequently advocated as arresting this situation. However, often such experiences are contrived and lack authenticity. This paper reports on how a group of Middle Years students used mathematics and technology to engage in a real community issue, of the need for a teenage safe space, to inform local Council policy. Data were collected for this case study via journal observations and reflections, semi-structured interviews, samples of students' work and videos of students working. The data were analysed by identifying the main themes that were connected with designing and locating the space and focused on the stages of the statistical investigation cycle used. How this impacted students' beliefs about the usefulness and value of mathematics is discussed.

Science and mathematics knowledge and skills are important for our increasingly technological and information-rich society. However, many middle years students opt out of mathematics and science as soon as they can. The review of literature by Tytler, Osborne, Williams, Tytler, Cripps, & Clark (2008) found substantial evidence that before students are 14 years old, they decide that they do not wish to pursue mathematics and science careers and are reluctant to change their minds. A new pedagogy is required to change students' perceptions about the value and relevance of mathematics and science.

Background

To cater for and nurture academic excellence in Middle Years students there is a need to design curriculum that involves them in authentic, meaningful activities with a real purpose. At the core is the view that to meet the intellectual needs of students in the 21st century they need to be given opportunities not only to *consume* knowledge but also to *produce* new knowledge that will benefit others.

The theoretical framework of this paper is located in the Knowledge Producing Schools (KPS) (Bigum & Rowan, 2009) pedagogical approach, in combination with the statistical investigation cycle (Wild & Pfannkuch, 1999). KPS is a variant of project-based learning where students work in teams to formulate and solve a problem or issue in their local community that is important to them. They are encouraged to formulate and model solutions to the problems on which they are working. Typically this might involve improving something in their local environment, solving a local problem, or designing and delivering a product for their local community that makes a difference. These activities: "produce some kind of product – be it a discussion, a story, a plan, a project or a product – that can be externally validated and which thus forms a bridge between school and not-school." (McGrath & Rowan, 2012, p.69)

In the KPS approach, the classrooms/schools become the organising base for learning but are not the only sites at which knowledge work takes place. The teacher is no longer the ultimate authority on the knowledge produced. Students draw on relevant expertise (not necessarily school personal) as required by the problem. The outputs are prepared for community groups who value what is produced and students develop new and interesting relationships with the local community and a broad set of experts. In this way, work results in 'products' that approximate, as closely as possible, *expert* productions in approach and

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quality. For KPS to be successfully managed, the teacher must be willing and able to establish partnerships beyond the school. They need to be able to source the necessary expertise to ensure intellectual rigor and genuine feedback. The teacher also needs the courage to take a risk and step back and allow the students and community experts to drive the process. Student engagement has been shown to increase when the students determine how they will achieve the goal (McGrath & Rowan, 2012).

The KPS framework proposes the following: students are positioned as the producers rather than consumers of knowledge and produce products with a genuine purpose and value beyond school assessment regimes; students are actively engaged and have a real world audience; all students and all forms of knowledge are valued; the audience facilitates a connection to the broader community which is involved in the actual learning process; and that the experience creates positive relationships between diverse children and knowledge, and between diverse children and the community. (McGrath & Rowan, 2012).

The statistical investigation cycle of problem, plan, data, analysis and conclusion (Wild & Pfannkuch, 1999) is used by statisticians and has been adapted for use by school students by Census@School in New Zealand (Figure 1). The first step in the cycle is to define the *problem* which includes understanding the context and how to approach the question. The *plan* stage includes: deciding what and how to measure; the design of the study; how to record and collect data. The *data* are then collected, managed and cleaned before the *analysis* where the data is sorted, tables and graphs are created, patterns are identified and a hypothesis is generated. The final stage is the *conclusion* which includes interpreting the findings to draw conclusions, communicating these appropriately and perhaps generating new ideas. This may also mean that it is necessary to go through the cycle again.

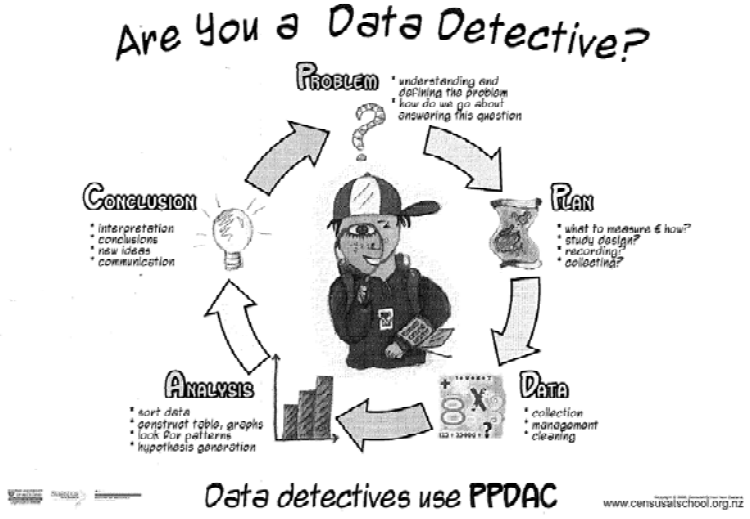


Figure 1. The statistical investigative cycle (census@school, n.d.)

Combining the KPS framework with the statistical investigation cycle provides a new mathematical pedagogical approach that suited the work undertaken with Middle Years students in this study.

The Study

This study brought together a group of twenty-seven Middle Years students (from Years Five to Nine) who were identified as Gifted and Talented, on the basis of their

general intellectual ability, specific academic aptitude, creative or productive thinking, leadership, or visual or performing arts skills. This provided a diverse group of participants with different talents and expertise, and a range of ages. The students called themselves Project Beyond Limits (PBL). Generally the students met weekly for about four hours, half in school time and half after school. They worked regularly with a teacher from the school and the researcher, a mathematician/mathematics educator, with input from the Council's Community Youth Development Officers (Youth Officers), a third year design student and the Youth Activity Space (YAS) Project Manager from the Council.

The Project

The brief for the PBL was to plan and design a project that would reflect their collective talents. The students decided that they wanted to create a *teenage-safe space* that was teenage safe, and also family friendly, would include multicultural artwork that represented the community, and had a landscaping and design element. They wanted seating and barbeques to encourage a wide range of people to use the park as a meeting place and to make a visible difference in their local community.

To bring this project to life the students approached the local Council to seek permission to build their teenage safe space. It was at this point that the project lifted from being real-life, to being authentic, as before Council was a plan to build a Youth Activity Space.

Methodology

Researching the work of the PBL adopted a case study design. Data were collected by:

- regular journal observations and analytical, critical reflections throughout the project by the researcher, who attended most sessions, and included discussions with the teacher;
- audiotaped interviews with students and the Community Youth Development Officer and the project manager;
- copies and photographs of student work;
- videos of some sessions while students were planning their strategy to petition Council.

The data collected in this project were analysed by identifying the main themes and issues that emerged, connected with designing and locating the space, looking for the 'working mathematically' moments and in particular the use of the statistical investigation cycle (Wild & Pfannkuch, 1999). The research question was, 'How did these students work mathematically as they solved their community problem to develop a *teenage-safe space*?'

Results and Discussion

This section focuses on the how the students used mathematics to communicate to the Council their preferences for the location and function of the YAS. Results are presented as stages in the statistical investigation cycle: problem, plan, data, analysis and conclusion.

Problem

Having identified two possible locations the Council needed to engage in public consultation. The chosen location was close to the community business centre and was perceived to be a safe public area due to the high frequency of passing adult pedestrians.

The business leaders were concerned about losing a car park and believed that it would attract an undesirable element to the area. Some staff from the school were concerned that being close to the school it would encourage truanting. However, staff who lived in the area believed the development of the site as a *teenage-safe space* would lead to a positive outcome for local young people. This location then became the students' *problem*. How could they plan a design concept, collect and present data that demonstrated the chosen location could enable students to feel safe and welcome?

Plan

For the *planning* stage, the Youth Officers worked with the students to decide how they would determine what the local young people wanted. The usual Council methods included: talking to young people in parks and shopping centres consulting with specific youth organisations, programs and services; conducting online surveys and discussion forums via Facebook and blogs; and marketing with posters, flyers and school newsletters. The students were concerned that they had no knowledge of, or input into, any of these consultation processes previously so they believed that these processes excluded a large proportion of 'everyday' young people. Consequently, they decided to personally hand a survey to every student in the two schools (later changed to every student in Year Five to Year Twelve). The students believed that this would give a much better representation of the views of young people aged up to seventeen or eighteen. This then was how they would *collect* their data.

The Council's main focus for the space was for a skate park as both locations adjoined other parks. However, students did not feel safe in either of these parks so they needed to design their surveys to enlist the support of other young people to ensure they would feel safe in the chosen location. One of the Youth Officers worked with the students to design the survey. (the other was transferred to another project.) The Council had assigned the bulk of the money for a skate park, but this was not the students' top priority. This meant the survey needed to include questions that reflected their aims. This was determining *what to measure*.

It proved challenging *to design* questions that could be easily answered by ticking a box but allowed their aims to be included without the questionnaire containing leading questions and therefore having experimenter bias. Students needed to consider what was included in the other major skate parks in the region that they had visited, for example, amenities, drink fountains, playgrounds, seating, barbeques etc. and how their aim of a teenager-safe space would be included. After writing the survey they waited a week and then answered it themselves. This led to further refinement of the survey as one student said, "I don't know what the question is asking. It made sense last week." Further changes were made when students were asked whether it would be possible to argue for their aims using responses from the survey.

> This provided 'Ah ha' moments for many students about what is involved in writing survey questions and how rewording questions made a difference to the way it is answered. This was highlighted by the comment, "Is it always this hard to write a survey?" (Researcher reflecting on student responses).

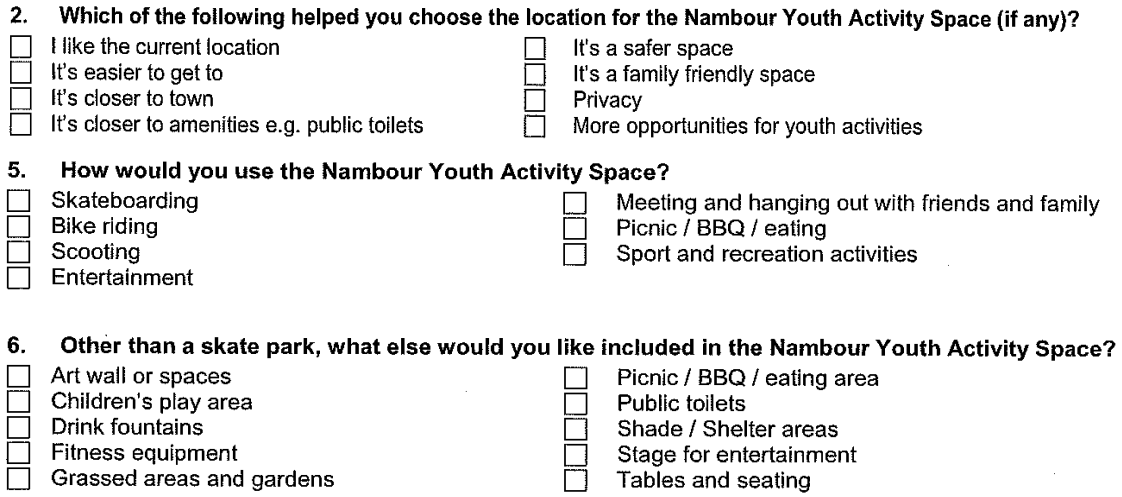
The survey was trialled with a couple of classes before the final version was decided upon. The Youth Officer's reflections on this process of designing the survey included:

> My role as development officer was to ensure young people had a voice in the process. … ensure they understood their roles and responsibilities … I knew the type of questions Council would want to know, the data they would be able to crunch … meaningful data, relevant data.

Researcher: But the questions weren't in quite the direction you thought they would go.

The Youth Officer: No … they are the experts in what young people want. … Young people had identified what they wanted in the space … a space inclusive of all young people … Council wanted a recreation space … young people wanted more than that - the social aspect. … I think it just came out.

The questions the students used to draw out their ideas are shown in Figure 2 with the response choices which included the safety issue overtly in question 2, and then covertly in question 6 with the possible inclusion of facilities such as children's play area, fitness equipment, picnic/barbeque/eating area, tables and seating and a stage for entertainment which would also appeal to adults. This inclusion of adults was important as an adult presence would discourage anti-social behaviour. Therefore students could collect data to inform the policy for a teenage-safe space that was inclusive of the whole community.



2. Which of the following helped you choose the location for the Nambour Youth Activity Space (if any)?

- ☐ I like the current location
- ☐ It's easier to get to
- ☐ It's closer to town
- ☐ It's closer to amenities e.g. public toilets
- ☐ It's a safer space
- ☐ It's a family friendly space
- ☐ Privacy
- ☐ More opportunities for youth activities

5. How would you use the Nambour Youth Activity Space?

- ☐ Skateboarding
- ☐ Bike riding
- ☐ Scooting
- ☐ Entertainment
- ☐ Meeting and hanging out with friends and family
- ☐ Picnic / BBQ / eating
- ☐ Sport and recreation activities

6. Other than a skate park, what else would you like included in the Nambour Youth Activity Space?

- ☐ Art wall or spaces
- ☐ Children's play area
- ☐ Drink fountains
- ☐ Fitness equipment
- ☐ Grassed areas and gardens
- ☐ Picnic / BBQ / eating area
- ☐ Public toilets
- ☐ Shade / Shelter areas
- ☐ Stage for entertainment
- ☐ Tables and seating

Figure 2. A sample of questions from the survey.

To achieve the largest response rate, with the *recording* and *collecting,* the surveys were handed out either on year level parades, or in class for the younger students. This was a logistical challenge for all involved and at times it was difficult for the teacher to maintain students' motivation. Groups of students spoke on year level assemblies or to individual classes about the survey, and then hand out and collect the completed surveys. Students impressed on their peers that by completing the survey they were having a voice in the decision-making. Eight hundred and thirty-six students completed the surveys.

Data

Data management included collating and presenting their data. Having prepared in advance Kerry, (Year Nine), led the discussion on how the surveys would be analysed. She discussed which graph would be the most appropriate and whether for some questions the mean, the median or the mode was the most appropriate measure to use. This was an interesting discussion as the students debated which type of graph would give a clearer picture and better support their argument as well as which measure of central tendency to use. The fact that much of the data was not numerical caused confusion for some students who just wanted to 'calculate the average'. This then became an opportunity to build some mathematical understanding about what these measures really meant, why you need more than one and which one to use in which situation.

Some students had drawn graphs using Excel but none had used it to collate data. The CYDO described how Excel was frequently used by the Council to collate surveys from public consultation and helped the students to set up a template to enter their data. Students were given responsibility for entering class sets of data into the template for analysis.

Analysis

To help students understand their data, the teacher gave some stimulus questions for each student to explore the data they had entered. This included: "What was the relevance of questions 2 to 6? Which location do the students prefer? What were the top two reasons for selecting this location? What was the most common way your students would use the … Youth Activity Space? What are the four most important features that are wanted in the new … Youth Activity Space?" This was a valuable activity for all the students who began to understand the reasons for the choice of data and all students had some experience analysing the data. For example, they were actively discouraged from counting the number of zeroes and ones in their spreadsheet and were instructed to use 'Countif' and/or 'Sum'. The students were then given a copy of two previous Council reports, as an indication of what was expected, and asked to allocate themselves to either the report writing or report analysing team. After spending many months waiting for the Council to make a decision on possible locations, the Council now wanted the public consultation to happen fairly quickly. The writing group developed an outline of 'report inclusions' and who was responsible for each section. This was sorting the data in preparation for communicating their findings. The teacher worked with the writing group and the researcher worked with the maths group.

The maths group divided the questions between smaller groups. Each group determined what type of graph would best represent the responses from their question, created it using Excel, analysed the graphs and presented those findings. This usually meant converting data to percentages either using a calculator or formulae in Excel. For these students who had never used Excel in class there was a lot of mathematical exploring and learning happening as they were looking to produce mathematically correct, persuasive results rather than the colourfully presented graphs they had initially wanted to use.

Four students worked on the demographic analysis, Matt (Year Nine), Tim (Year Eight), and Jim and Callum (Year Six). The survey had collected data on age groups, gender, and which suburb the students lived in. Once the graphs were drawn, the researcher asked whether their sample was representative of young people living in the area. Following this discussion the demographic group visited the Australian Bureau of Statistics website to collect data about where young people in the region lived to determine whether the school population was similar to the total population. They calculated the percentage of young people who responded to the survey compared with the total population of young people aged 5 to 19 that lived in each suburb in the region. This provided an "Ah ha" moment for Matt:

> I worked on the demographic analysis. One of the things I learnt was how to work with percentages. How to calculate them from just ordinary numbers.

This is an interesting statement made by a high achieving Year Nine student who has been 'doing' percentages since Year Six. Students find percentages notoriously difficult (Hãwera & Taylor, 2011). This is due in part to the need for the learner to make connections between fractions, decimals, ratios and proportions (Reys, Lindquist, Lambdin, & Smith, 2007) and the need to consider the percentages in the context they are working in (White & Mitchelmore, 2005).

Tim also commented that the demographic analysis had improved his mathematics and computer skills.

> While doing the report for the Council I extended my knowledge of doing both maths and computer skills. PBL also helped me with my team work and my time management.

Jed in Year Six was excited about the usefulness of the mathematics he was doing.

> I enjoyed PBL because we actually got to do something useful in the community instead of just doing maths sitting in the classroom. We could actually go out there and design a skate park, something awesome.

Conclusion

For the conclusion of the statistical investigation cycle the students wrote a report and presented it to the local Council. Students needed to *interpret* their data, draw *conclusions* and *communicate* these findings to the Council. For John it was linking mathematics with the real world has helped to deepen his knowledge of and appreciation for the usefulness of mathematics:

> Being part of Project Beyond Limits has let us work together outside school time. This has extended our skills beyond core subjects using the real world.

Figure 3 shows a small section of how one student (John) communicated his findings on how the students would use the YAC.

> This concludes that the students of ... High School and … State School surveyed would prefer to use the new ... Youth Activity Space for meeting and hanging out because almost half of the students selected this as their preference for question 5."

Figure 3. Part of the report showing how the students would use the YAS. (NSHS and NSS, 2012)

The project manager from the Council was very supportive of the students' efforts writing:

> The students provided much support and information that aided in the successful site relocation … the students and teachers involved played a vital role in the success of this project. The community would not have this outcome without the assistance of the Project Beyond Limits Team.

He believed that it was the students' report that swayed the Council to accept the young people's choice of location:

> [T]he collective information that the students provided in their report was used as additional evidence to further support a report that was compiled internally … the students report strengthened the argument for the endorsement. The critical aspects of the report that were used were the number of people surveyed and the outcomes of the survey, for and against the relocation.

The Council minutes of the meeting indicated that the motion was passed thirteen to one and that one member raised a point of order that was upheld regarding people speaking out of turn (Sunshine Coast Council, 2013). This reflects the fiery nature of the meeting and the conflict between the young people and the Business Alliance.

Conclusions

This paper discussed how a group of students used mathematics to communicate the desires of the young people in the community to the decision makers in Council, influencing local policy. As the students worked through the statistical investigation cycle they identified their problem, planned an approach that included designing a survey, collected data by surveying the students in their schools, collated and analysed the results of the survey, and concluded by writing a report which they presented to Council. The

report highlighted the young people's desire for a teenager-safe space that was inclusive of all members of their local community. Utilising a KPS pedagogical approach, the classroom teacher from one of the schools enlisted support from a Council Youth Officer and a mathematician/mathematics educator from the local university to work with these students. Through this project these students saw the value and usefulness of mathematics as they developed their knowledge and skills of a number of mathematical concepts including percentages, mean, median, mode, graphing, writing survey questions, and analysing statistical data. The value of this KPS pedagogy was highlighted by a high achieving Year 9 student who learnt "how to work with percentages. How to calculate them from just ordinary numbers." It had taken this project for him to develop a deep understanding of percentages rather than his previous procedural understanding.

The students were proud of their efforts to make a difference in their local community and the mathematical, statistical, computing and social skills and understandings they learnt along the way. Jack in Year 8 summarised this with:

> During PBL I have learnt many skills like, how to work in a team with many people from different age groups. This has helped learn how to use other people's skills. It is also very good and I learnt many things on the computer, such as graphing and how to analyse certain questions like in the report that we did and it's a very fun experience and I've learnt many things.

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