DATA HANDLING FROM A CLASSROOM PERSPECTIVE IN THE UK

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An approach to teaching Data Handling across Secondary Education, using CensusAtSchool and related data handling material to develop secondary students' knowledge of statistical techniques, alongside the development of skills of interpretation and analysis. The approach increases both confidence and capability when handling data. This will be framed in the context of a student population with low expectations of themselves and low aspirations. The students are motivated and engaged using the CensusAtSchool project, which, by using their data has a positive effect on both teaching and learning.

CONTEXT OF THE SCHOOL

In September 2005 Upper Avon School relaunched itself as a Specialist Sports college and became Avon Valley College. The change from school to Sports College marked the end of a somewhat chequered past with difficulties in terms of Ofsted inspections and disappointing exam results. Avon Valley College is situated in a beautiful part of Wiltshire; it is 9 miles north of the city of Salisbury, 3 miles from the historic Stonehenge site and on the edge of Salisbury plain – an area some 20 miles long and 16 miles wide that is used for a combination of farming, English Nature preserve and Army Training. The area is an idyllic setting, both picturesque and steeped in history. In reality the catchment area of the school is one of rural deprivation. It includes wards with particularly high rates of teenage pregnancy and of disaffection within young men. The academic intake of students is low, regularly averaging less than 27 points (i.e., below level 4 of the UK National Curriculum, and below the average expected to be reached by the age of 11). This, combined with significant transience of students due to 40% coming from an armed forces background, cause unique problems for our young people.

In September 2000, the school underwent an Ofsted inspection and was placed in Special Measures. It came out very quickly and was re-inspected in March 2004. The Inspection report included comments such as "many pupils show relatively low levels of confidence and ambition" and "Pupils generally have relatively low personal aspirations." These comments really did sum up the students; they were lively and friendly, but did not have a great deal of confidence in themselves and were unwilling to take any responsibility for their own learning. Teaching was reported as being good but learning was not and the challenge was set to raise the aspirations of the students, to give them more confidence and to turn them into independent learners.

NATIONAL DIRECTIVES

I began teaching at Upper Avon School in September 1996 as a newly qualified teacher. At that stage the UK National Curriculum had been in existence for some seven years. The National Curriculum made explicit what statistical ideas and techniques needed to be learnt but did not emphasise the idea of applying these techniques so as to understand and interpret data. In September 2000 the revised National Curriculum came into effect and was followed by the Key Stage 3 Strategy in September 2001 marking a sea change to the approach of teaching Data Handling. The Key stage 3 Framework for teaching Mathematics (for pupils aged 11-14) placed an emphasis on direct and interactive teaching methods: For the attainment target of data handling, the framework set out to specifically:

- Base work on *purposeful enquiry*, using situations of interest and relevance
- Place an emphasis on *making inferences* from data, drawing on a range of secondary sources to ensure that the samples are sufficiently large;
- Use ICT as a source of data and as a means of processing data and simulating situations.

This gave a very clear direction for teaching data handling.

Following on from the key stage 3 strategy, GCSE examination boards also began to revise their specifications and in 2003 introduced a Data Handling Project that accounts for 10% of the final GCSE grade. The project style piece of coursework meant that the assessment of data handling was split between assessing the technique itself in the examination paper and assessing interpreting, understanding and communicating in the coursework.

Both of these two strands – the Key Stage 3 strategy and the GCSE Data Handling project have had a significant impact on the teaching of Data Handling in Schools. Many teachers were delivering high quality, interactive lessons and were using real life situations as a matter of course but the implementation of these National initiatives pushed Data Handling to the fore. Certainly within my relatively short career the emphasis has changed and the challenge has been to take the current educational thinking and to be able to apply it practically and appropriately within the classroom.

CENSUSATSCHOOL PROJECT

In September 2000, a leaflet came to school advertising CensusAtSchool. We saw the Census as an opportunity to relate mathematics to a national event and to give students the opportunity to see mathematics at work in a real life context. The whole school took part in the CensusAtSchool and every student filled in a questionnaire within Maths lessons. A group of year 11 (15/16 year old) students took on the role of amanuenses and transferred all the data onto spreadsheets and uploaded via the Internet. These students had taken their GCSE maths early and were starting GCSE Statistics so it was a really useful exercise for them to deal with problems like – what happens when you can't read what is written? Or what about the person who claims their foot measures 2.5 cm?

Completing the first CensusAtSchool census was an experience for us – both staff and students alike. It was new, topical and involved practical skills, but more importantly it gave students the chance to talk about themselves and to compare themselves, albeit informally, with others. Analysing the results of the school brought some interesting revelations – 80% of students in our school at that time had mobile phones, PE was the most popular subject with Maths in second place. It created a real buzz in the Maths department and raised the profile of Maths across the school because students were talking about the Census and the results with their tutors and other subject teachers. The first step towards getting students enthused about their work and communicating with each other had been taken.

It would have been easy, at this stage to be satisfied with the success of the project and to write it into a scheme of work for repetition annually. However, we had come to recognise the power of using personalised data and we had so much of it that we decided to build on the project. The first experience of completing a GCSE Statistics coursework and a GCSE Data Handling project was that students could find the mean, draw a cumulative frequency curve etc but could not interpret their data, they could not put a meaning to their results, so the challenge was to prepare them at younger age, developing these interpretation skills before they embarked on GCSE course.

Since 2000 our data handling work across key stages three and four have developed. In Key Stage 3 we follow the National Strategy scheme of work – adapting it to suit our students; it has a cyclical nature in that topics are revisited over the three years and we split data handling into two distinct areas. We teach statistical techniques – collecting data, finding averages and drawing a range of statistical charts. These techniques are then applied to a statistical project in each school year. Consequently, our students get opportunities (within a relatively short space of time) to learn a technique and then go on to apply it to a relevant situation and find something out. We vary the projects from year to year:

In year 7 (for students aged 11/12) we look at historical data in "The Gravestones project," students are given sheets of data to analyse and sort the data into groups, find averages and look at what is the most appropriate graph. We develop the project side of the work so look at hypothesis testing and comparing distributions, but we have a very structured, often whole class, approach with an emphasis on interpretation and asking questions - for example - if you were born 200 years ago, what age would you expect to live to?

In year 8 (for students age 12/13) we keep the learning vibrant by involving ICT as a vehicle for completion of the CensusAtSchool. Year 8 students complete the Census during their ICT data handling unit, and use it as an example of entering data into an online database. In Maths lessons students then use their OWN data to compare themselves with their class and with students in other countries. Use of their own data is very powerful. Without exception the first thing students do is go down the list and find themselves (by their height, or their data of birth or postcode…) Students find it much easier to relate to statistics if it is about something they know about – and what better than themselves? Investigations differ from year to year and from teacher to teacher: the power of personalising projects applies to teachers as well as pupils. We have compared ourselves with one country and with many countries. Given the context of the school and the semi rural environment that many students live in, it is an opportunity for students to consider how different cultures live and to think 'globally' as well as an opportunity to practice their mathematical project skills.

In year 9 (for students aged 13/14) when SAT exams are over (national exams taken by all 14 year olds in state schools), we embark on GCSE coursework. Investigational coursework first, then after half term – a pre-data handling project. Here we really concentrate on project skills, hypothesis testing, sampling, and bias and collection of data. The idea is that we 'skill up' students so that they are ready to tackle a Data Handling project in year 10 (for students age 14/15). There are lots of resources on the CensusAtSchool website that we use for skills teaching but we also use the Census data for this mini project. We have a pack of our schools data from the original census, as well as student responses from year 8 and use these to investigate hypotheses. Wherever possible we use data that is about an individual student. A few examples of hypotheses we have used are:

- Taller people have bigger feet regardless of age.
- Time taken to travel to school depends on the distance of home from school.
- Those people with more people have more cars.
- School subjects that involve physical activity are more popular than other subjects.

So the overall plan is structure in year 7, more freedom in year 8, then back to a more structured approach in year 9, scaffolding a full project. All aspects of key stage 3 work involve students own data and we ask them not just to perform a statistical technique but to analyse it – to say what does this mean? Why is it? By year 10 (and the onset of GCSE) we aim for students to have the necessary statistical skills but also the communication skills required to tackle a full blown project. Students are in this position because they are used to having ownership of information.

GCSE COURSEWORK

In year 10 we want students to be inspired. In the summer term, students come off timetable for two weeks to undertake work experience. We start the Data Handling Project just before work experience, deciding on the hypothesis and planning the project. Over the work experience period we then expect students to collect their data and most choose to collect from a real working environment. We ask students to set their own hypothesis as that way they are studying something that interests *them*. Some students still choose to use CensusAtSchool material, other students have their own ideas and to be honest – at this stage, these tend to make the better projects. For students who are generally not willing to take responsibility for their learning, coming up with their own project is in itself a breakthrough. To then spend time away from the classroom, collecting data from a real-life, tangible context is a real achievement.

The following extracts come from students' projects to illustrate the level of work that is produced. All of the examples are from Intermediate students – i.e., students of average ability.

The first hypothesis is "Older cows produce more milk than younger cows." Matt spent two weeks on work experience on a dairy farm and collected data on the name of the cow, age, number of calves, amount of milk produced at each milking. Danny – a golf fanatic, came up with "You can hit a ball with a driver a further distance off a tee than the ground, but you can hit a ball with a no. 7 iron further off the ground than off a tee." Danny spent two weeks working on a golf course and asked people to hit a ball with a driver then with a no 7 iron, he asked each person to

hit the ball three times with each type of club. This was fairly complex data collection, how do you measure the distance? Do you use all the results or do you use the mean for each person? Or the median? Which is the appropriate average? How do you select the people to hit the ball? Lucy came up with "Coronation Street uses a higher level of language than EastEnders." She videoed the omnibus edition on Sunday and took a sample of dialogue, recording the first sentence spoken in each minute of the programme. She compared word length, sentence length and made decisions about what would constitute a higher level of language. She went away and researched readability statistics looking up the formula for the Flesch Reading Ease score. None of these students would be confident to come up with these sorts of hypotheses had they not been confident data handlers.

During the project itself students continue to display high levels of communication skills and insight into their understanding of what it is they are trying to achieve. Again, all comments come from Intermediate students.

In Danny's Golf project he wrote "When I collected my data I collected primary data, this is where I collected the data myself, and to verify my results I will collect secondary data." So Danny had understood the difference between primary and secondary data and he was then going to go on to research external statistics that he could use to verify his own results.

Sophie collected data from students in the school. She wrote "I shall be using proportional stratified sampling, meaning that I will be using proportional amounts of people from each year group. Once I have identified the number of students I will collect data from in each year group, I will then go on to use systematic sampling where I will take a list of names in the year group arranged in alphabetical order and select every x^{th} person. I will calculate x by number of people in the year group divided by the number of samples required." Sampling techniques are not part of the Intermediate tier syllabus but we feel that by teaching beyond the syllabus and giving students actual sampling techniques to use we increase their understanding of the data collection process and help them understand how to collect a fair sample of data.

Chloe went to work in a pre-school and investigated short term memory in young children, looking at the types of information children could recall. She then collected data from an older age group to compare results. She represented two of her test results on a scatter graph. "The scatter graph shows older children generally had the highest score, although there were two anomalous scores." From quite an in-depth project she was able to represent her data, think about results that did not follow the norm and go on to consider why that might be the case.

Once the Data Handling projects are finished and conclusions are drawn, students are encouraged to consider the limitations of their projects and to consider how they could be improved and to consider the purpose of their project. Matthew investigated height and foot measurements using the CensusAtSchool data. He wrote "Finally I will look at the practical consequences of my work and the main consequence that I can think of would be if I were to do a more extensive sample and still found my hypothesis to be true then it could be used in practical purposes. For example Archaeologists who find bones would be able to predict the height of a person from their foot length and vice versa and this would be helpful."

We are very proud of our students and the work they do in their data handling projects. They display high levels of communication and understanding and they show that they can apply their mathematical knowledge to real-life situations. Students are showing independent study skills and developing project skills that are helping them in Maths lessons, starting to influence their work in other curriculum areas and, more importantly, will equip them to understand and use informed analysis throughout their lives in an increasingly data driven society.

To summarise our approach, we spend Key Stage 3 emphasising interpretation of data. The success of teaching this skill still lies in the ability of the Teacher to ask questions and to challenge students to think. This is a much easier task when students communicate confidently as they do when the data they are using is in a context they understand. What the CensusAtSchool project does is give us a vehicle to collect data from students and then use it. In Key Stage 4 we encourage students to expand their horizons and consider problems and projects that interest them. They do go out and do this because they are used to using data that is relevant and real. As teachers we feel this approach is successful because students engage with data and talk about the mathematics they are doing. Students are now prepared to express and to share their own ideas.

The approach has been a major factor in exam success. Maths GCSE results have steadily risen from 43% A*-C in 2001 to 59.3% in 2005 – our best ever. I firmly believe this is because students have been challenged to think throughout their secondary school experience and have developed independent study skills. The data handling work has taught them to ask questions about their work, to communicate clearly – both written and verbal communication and has taught them how to break down and tackle a problem. Our exam board Edexcel has recently developed a service where a Centre can receive analysis of examination response question by question. Looking at the breakdown of individual questions, students from Upper Avon achieved above the National Average mark in every Data Handling question and this was particularly evident in the Intermediate and Foundation tiers.

CROSS-CURRICULAR DATA HANDLING

Numeracy across the curriculum is nothing new - in spring 2002 as part of the Key Stage 3 Strategy all schools were expected to devote a whole-school training day to numeracy across the curriculum but this covered mental and written calculations, and measures as well as data handling. It was an opportunity to scratch the surface of the topic but not enough to set up long term collaborative projects across schools and not enough to help teachers understand the difficulties students can have in recalling and applying a technique in a new context.

We are now expanding our horizons further and looking at cross-curricular work. The prevalence of the Internet in schools has expanded the amount of data available to teachers and students. There are far more instances of teachers asking students to go away and collect data and analyse it than there were five years ago and teachers across the school are expecting far more from students in terms of what they are able to do with the data. The next challenge is to convince students that the skills they have learnt in Maths lessons by doing the data handling project are commutable, and can be transferred to other subjects. Part of this process is confidence building (both students and teachers) and part is sharing best practice.

Within the school we have formed a small working party looking specifically at data handling. We started by looking at the expectations different subjects have of their students in different age and ability groups and we have moved on to looking at common teaching strategies and approaches to recapping skills. We are moving to a position where we can team teach data handling sections to help convince students that working with data is not confined to a Maths classroom but is a transferable skill. If we are to look at School Improvement, all subject areas need to be working in collaboration to improve the skills of students so that they operate at a consistently high standard across a range of subject matter.

THE FUTURE

So what does the future hold for Data Handling in schools? Without doubt the skills of Data Handling will be called upon more and more as data continues to be readily available on the Internet and as we continue to live in a data rich society. We need to be innovative in our approach to cross curricular project work, considering the students and encouraging them to be independent learners, taking skills learned in one area and apply them to others.

At Key Stage 4 subjects feel pressure to cover exam board syllabi prior to exams. Each subject has a coursework element and data handling is integral to this in many subjects. We should work collaboratively to decrease the number of pieces of coursework a student produces whilst increasing the quality. I propose that with teachers working together one piece of coursework could be produced and then marked and submitted for a number of different subjects in the same way that Maths data handling projects can currently be submitted as Statistics GCSE coursework (provided they are re-marked under the statistics marking criteria). We, as a College will develop this for our students but standardisation at the national level would be most helpful.

Technology continues to develop and we need to use the technologies that we have to help us and be proactive rather than reactive. Many schools are beginning to use ‘Portals’ to share work between school and home, to communicate with Parents, to give access to work done in school in cases where a student is absent through illness or is unable to attend school for a period of time for any reason. This technology could arouse the involvement of Adults other than Teachers in the development of statistical awareness in our young people.

CONCLUSION

The last five years have been steep learning curve in terms of teaching Data Handling. We have moved from a position of only teaching statistical skills to a situation where we also teach interpretation of those skills. Students started from a base where they were not risk takers, did not work independently and (despite having good teachers) were not good learners. We took a strategic approach to data handling and planned work across year groups and key stages. There were definitely two strands to our strategy – one was to develop data handling project skills, for students to use the data handling cycle confidently and competently. The other strand was to develop wider skills, those of independent learning, of independent thought and application of Number. Using data in context has been key to both strands but the data had to be in a context that students understood and could relate to. What the CensusAtSchool project did was give us the data in context and therefore gave us the tools that we could use to begin inspiring students. Our students now are more confident than ever, their communication skills have improved greatly, not just in data handling topics but in all mathematical topics. They enjoy the work they do and at the end of their GCSE course genuinely do have skills that they can take out into the workplace and use. Most significantly, this emphasis on personalising the curriculum has impacted on the two major foci for school improvement here at Avon Valley College; to raise the aspirations of our students and to develop a responsibility in them for their own learning.

REFERENCES

Key Stage 3 National Strategy. (2001). 19.