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Statistics is pervasive throughout society. Anyone who picks up a newspaper, listens to the radio, watches television and so on cannot avoid statistics. Organizations constantly provide the public with statistics to convince them that, for example, the economy in improving, business is expanding, the cost of living is not increasing very fast and so on. As well as finding statistical information in all walks of life, statistical information is found in all areas of curriculum, whether it is data on population trends in geography, data collected in a science experiment or data for investigation in mathematics. Statistics is truly interdisciplinary. Specifically the importance placed on statistics is reflected in the Mathematics Syllabi of Singapore (MOE, 1990).

The teaching of statistics often involves three phases; Data Collection; Representation; and Interpreting and Predicting (Pereira-Mendoza and Dunkels, 1989) (See Figure 1). However, they will have a limited impact on students' learning unless the activities are embedded within an environment in which the information has to be
communicated. In teaching statistics we, as teachers, need to emphasize the role of communication. Furthermore, any problems posed should be meaningful and of interest to the students. This leads to the expanded model for approaching statistics in the classroom.

FIGURE 2
This model is consistent with that presented in the Framework for Mathematics Curriculum (Mathematics Syllabus, p. 3). In the Ministry framework Mathematical Problem Solving is placed at the centre with the attainment being dependent on five interrelated components; one component, Concepts includes statistics, while another Skills includes communication.

In order to illustrate how this model can be applied in the classroom three projects are suggested. The first is a short project, while the others will take longer to complete, possibly involving an extensive period of time. They are exemplars of both potential areas for projects as well as of specific projects that could be undertaken. There are certainly many other areas as well as of specific projects that could be undertaken. There are certainly many other areas as well as alternative projects that could have been selected. These exemplars illustrate the interdisciplinary nature of statistics teaching in the school.

The general approach to the projects has been outlined, rather than including many specific details. Also, some issues that the students have to address when tackling the projects are included in the discussion. The first activity contains two "Suggestion Boxes". The suggestions are based on questions that have often arisen in discussion. They should give you some idea of issues that might arise when using the activity as well as some ideas of issues that you could raise during the activity. As you use this or the other activities, students will raise other ideas and you should take advantage of these as they arise. For Projects 2 and 3 you might like to develop your own suggestion boxes prior to using the activity. Finally, it is worth noting that although the expectations for the level of analysis and sophistication of presentation would vary according to the level of the students, the particular examples selected can be adapted for use in both elementary and secondary schools.

**Project 1: How do students come to school?**

There are many activities that can be undertaken involving transportation. One involves collecting information on how students come to school. Collecting data on this is suggested as a possible
activity that can be undertaken in Singapore Schools (Primary Mathematics 3B, Teacher's Guide, 2nd. Edition, p. 64). In this context it is suggested that the activity could be used to develop a bar graph. Later the use of "how do students travel to school" is suggested as an activity that can help students read and interpret pie charts (Mathematics Syllabus (Primary), p. 88). The following project is an extension of the basic idea.

**Problem**

Make a graph and report on how children travel to school. This graph and report will be placed on the wall for all children in the school and your parents to look at.

**Data Collection**

What data are you going to collect? Will you collect the data from just your class or from different classes? Does the day of the week matter? Does the weather make a difference? These are all questions the class should address. You can divide the class into groups and have each group decide on what factors they need to consider. Different groups may decide on different ways to collect the data. This is fine.

Later on, after the displays are developed and reports written, the different approaches can be compared and the advantages of each discussed. The discussion both within and between groups (communication) plays an important role in helping the students developing their approach to the problem.

**Representation**

The choice of representation is a key to communicating the data accurately and clearly. If students select a bar graph one of the most important factors that they have to consider is scale. This can lead to an interesting discussion about different scales and the way this creates an impression. For example, the size of the increments in a bar graph, or the size of the circle in a pie chart can give very different impressions of data. Huff's book (1954) provides an
Suggestion Box A

In discussing how to collect the data, some of the questions that might be raised are:

(a) Should the data be collected from the class or the school?

You could suggest that different groups do different things and compare the results.

(b) Who should collect the data?

Having one student in each group collect all the data is possible if you limit the data collection to a single class.

(c) If you use more than one class, each student in a group could be responsible for a different class.

(i) In this case they have to decide how to assign the data collection. One way this can be done by putting the class name/number into a hat and have members of the group pick out classes. Then each member of the group asks the individuals in that class how they travel to school. The data for a particular class should be collected on the same day.

(ii) Alternatively, a note could be duplicated and distributed to each student in the classes and they could be asked to say how they travelled to school that day. The note could list the different types of transportation (bus, car, MRT, bike, walk,...)

(d) Should the weather be taken into account?

Students can decide to collect data on two different days. One day when the weather is fine and another when it is raining. They can follow the procedure in (c).

Similarly, if they decide to look at different days of the week.

(e) Each group can be encouraged to present what they plan to do to the whole class. This can be discussed and provides an opportunity for suggestions from other students and the teacher.
Suggestion Box B

In discussing how to collect the interpret and report the data some questions that might be raised are:

(a) If the students have used different graphs to represent the data, the students could be asked:

   (i) Which one would be clearer to someone visiting the class?

   (ii) Is one representation better if you have collected data from a single class and a different representation better if you have used the whole school?

You might find that a bar graph is the best arrangement to compare classes.

Note: In doing this it is important to allow different graphs and reports to be displayed. Then the students can see that different displays may have different strengths and weaknesses.

(b) Suggestions for improvement of draft graph/report.

Some suggestions that students have found useful concern the practical aspect of making the graphs (clearly labelling axes, making sure the scale is clear, etc.)

Also, students often do not include information on the data gathering (e.g. if they interviewed the students what did they ask, was the data collected on a rainy day, what day of the week, etc.) These could be important for later discussion when graphs are compared.

Ask the students if someone who has not been part of the class could read the graph and report and understand the information. You can then make specific suggestions depending on the difficulties.

(c) Follow-up

Students could be encouraged to get similar information from other schools and compare. You could have the class decide on a common question and the best representation of the information to compare data. A bar graph works well.
interesting source for a discussion.

Interpreting and Reporting

As suggested earlier the students can work in groups to create the graph and report. The displays and reports could initially be presented to the class to comment on and make suggestions for improvement. The advantages and disadvantages of different types of graphical representation should be discussed. If some groups collected data on a rainy day did it make a difference? If the weather was important, then information on the weather when the data were collected should be included in the report. If some classes collected data from different classes this needs to be included. The student can be given an opportunity to make changes prior to the displays being made more generally available for viewing. A key aspect is the feedback as to why some representations are clearer than others.

It is not a matter of determining whether one way of collecting information or representing information is better than another, rather the goal is to develop communication skills when presenting a statistical argument. Through this type of discussion/activity students will be better able to understand the nature of data and the importance of choices regarding representation. The sophistication of the selection of a sample – if a sample of the school was chosen – or of the graphical representation will depend on the level of the students. Expectations can be adjusted according to the experience and ability of the students.

If data were collected from a single class, students can be asked to predict how they think students travel in other classes? Does the level of the student (e.g. P1, P4 or JC matter)? What do they think might happen in other schools?

Project 2: Sports

There are many activities written involving the collection and analysis of sports data (e.g. Olson, 1987; Burrill, 1988). With the upcoming Olympics being held in this part of the world it is an ideal time to discuss a sports project. The following scenario can be presented to your students.
Problem

You have to make a case for the inclusion of a new sport in the Olympics. You will be allowed to make a presentation to the selection committee and provide them with a written report.

Data Collection

What data would be needed to start to make a case? This is an important question when undertaking a statistical project. If the objective of the exercise is to develop an argument to support a particular viewpoint, then it is essential that the argument be supported. Some of the data students might try and collect is: (a) How many people play the sport?; (b) How many people watch the sport?; and (c) Is it played in many countries? As with the first project, the communication between the students plays as key role in the decision making process. In addition to this general information, a local survey can be undertaken to try to gather some data on this topic. The sophistication of the survey will depend on the level of your students.

Representation

How can the data best be presented to make the argument? For example, soccer is played by millions of people in many countries. It is also has an enormous world-wide television audience. Would this information best be represented by a bar graph? Maybe it would be better to use Stem-and-leaf plots where one can compare the audience for soccer with other sports? These decisions are essential in deciding on how to communicate the information in the most effective manner.

Interpreting and Reporting

How can the results be interpreted? How should the report be written? The purpose of the activity was to make a case for the new sport. At this stage the students have to decide how to discuss the data in the most effective manner to make their case. The fact that different "experts" might interpret the data in differing ways is an important consideration. Consequently, as well as developing
exploratory data analytic techniques, this activity helps students develop those skills needed to formulate an argument. It is one thing to collect, represent and interpret data, it is another to utilize this information to convince others. If statistics is to be used as an effective means of communication this is an important component of students' education.

The students would then present their findings to the class. The feedback they obtain could then be used to refine the report and presentation. Finally, the students could make a presentation to the School Council, School Trustee's, or another group. This component should help the students see both the value of a well prepared argument, as well as other considerations that might be part of a final decision. Well supported argument will not necessarily bring the expected results. This is an important lesson if students are to understand both the value and limitations of using statistical information within an argument.

Project 3: Environment

The environment is at the centre of many discussions. Whether it is the effect of logging on the environment, recycling or the potential for destruction of the ozone layer, debates on environmental issues can be found in newspapers, television, textbooks; in fact, in all media. The following problem is one that can be addressed at a very local level.

Problem

Should your community or school start a recycling project? You have to make a proposal to show how this will be of advantage to the community or school.

Data Collection

What are the advantages of recycling? What will it cost? How can we do it? These are some very basic questions that need to be answered before a recycling project can be undertaken. The starting point for data collection might be to contact various communities
where recycling has been undertaken and collect appropriate data about their project. Find out how much garbage is produced in your own area. How is it disposed of and how much does it cost? This is just the starting point for data collection.

**Representation**

Having collected the information, decisions have to be made on how to represent the information. Should tables be used or are graphs going to have more impact? If graphical representations are selected, which data should be included. How do you represent your community versus other communities? These questions lead to an understanding on the role of representation in statistics. An effective representation may be key to making your point; the representation may do most of the communication.

**Interpreting and Reporting**

The information has to be incorporated into a proposal for a recycling project. In the case of a school recycling project the data collection is relatively limited and the project is appropriate for the elementary school. A case for a community recycling project is far more complex and is more appropriate for secondary school. However, the end product should be a report in which a case for recycling is made to "outside" people.

**Conclusion**

As indicated the projects suggested here are only exemplars. For example, alternative questions involving trying to convince an audience that one sport is more popular than another, or that students are more likely to get hurt in one sport than in another and so on could be explored. Collecting data on types of vehicle in use in Singapore can be undertaken. This involves some interesting issues about where the sample is collected, what time of day and so on. Similar alternatives can be found in the other areas. The key is to use the data in a situation where an argument has to be made to a third party. If communication is to an important objective of mathematics education, *it is essential that the development*
involves an emphasis on communicating mathematical ideas both to other students, the teacher, as well as to people outside the classroom.

All these activities involve problem solving. Students have to make decisions at various stages during the activity, and the ability to make appropriate decisions is an important part of the problem-solving process. Finally, there are many ideas for statistics activities in the literature. It is not necessary to "re-invent the wheel". Rather it is better to refine and adjust activities that have already been shown to work. One only has to pick up virtually any issue of the Mathematics Teacher, Arithmetic Teacher, Textbooks or Teacher’s guides to find appropriate statistics activities. What is being suggested here is adapting and extending some of these ideas to better develop statistical ideas, communication and problem solving.

References


