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## AN INTERNATIONAL OVERVIEW OF DATA ANALYSIS WITHIN THE MATHEMATICS CURRICULUM

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### **Abstract**

Mathematical education has radically changed, in many countries, over the last decade. The need for mathematically literate students who can function in today's technological society has instigated change in the content of the mathematics curriculum. In the United States the Quantitative Literacy Project placed emphasis on data analysis and this provided the key components of the new mathematics curricula. The National Research Council (1990), suggests, "Most obvious, perhaps is the need to understand data presented in a variety of different forms...Citizens who cannot properly interpret quantitative data are, in this day and age, functionally illiterate". The National Curriculum in the United Kingdom also attached a great deal of importance on data analysis, within the mathematics curricula. In developing countries, such as Pakistan, the shift from rote learning, of numerical techniques, is currently taking place with data analysis taking a prominent role. The Universities advisors of Pakistan identified the need for the students, within the school system, to be aware of and become familiar with the growing developments in data analysis. The purpose of this paper is threefold namely to give an overview of the implementation of data analysis in various countries; to compare and contrast data analysis in these countries and to elucidate the importance of data analysis within the mathematics curriculum.

### **Introduction**

The aim of this paper is to present an overview of data analysis that is currently being taught in various countries. The countries under consideration are grouped into three main areas namely the Europe, America (North and South) and third world countries, other countries will be mentioned specifically by name as and when is necessary. The basic concepts of data analysis that are currently being taught will be elucidated along with current examples that are used in teaching and understanding of these concepts.

## **Overview**

Data analysis is a relatively new topic in mathematical education, especially when compared with, what is termed as, traditional mathematics such as trigonometry or algebra. Tukey (1977) states, in the preface of his classical book *Exploratory Data Analysis*:

This book is about exploratory data analysis, about looking at data to see what it seems to say. It concentrates on simple arithmetic and easy-to-draw pictures. It regards whatever appearances we have recognised as partial descriptions, and tries to look beneath them for new insights.... both teacher and student need to realise that many problems do not have a single 'right answer'. There can be many ways to approach a body of data to find the good way to approach it, may require a key, whose finding is a creative act.

This quote emulates what, in today's educational system, is data analysis. Tukey is often referred to as the forerunner of *Exploratory Data Analysis* (EDA). The global implementation of data analysis is wide ranging, varied and at various stages throughout the world. The following examples elucidate some current practices which the reader can then follow up at their leisure.

## **Current examples**

Research projects have been set up by some countries, such as those in North America, to look into and to implement new mathematics curricula. These new curricula place emphasis on the understanding of data, that is presented in a variety of formats and on many different mediums. Examples from North America include The Quantitative Literacy Project Programme (Burrill,1992). Statistics Canada have produced numerous classroom activities involving data analysis that can be used in mathematics lessons or in a cross curricula context such as geography or social sciences classes. This year Statistics Canada have produced a Census Teacher's Kit as part of the census awareness programme. The Kit is designed to inform students of the many uses of census data and its importance to the country. Grade levels are indicated on each activity and all the necessary tables, charts and data have been included to make the Kits easy to use. Each census Kit is sent to every school in Canada. This is an example where the government, of the country, have set up an external body to produce materials which is of maximum benefit to teacher and students alike. All activities have been prepared with the help of professional educators and have been classroom-tested in English and French for suitable content and grade level.

Vasco (1994) from Columbia, South America in his paper 'Handling Data Systems in the Curriculum for General Basic Education' describes the decisions made about statistics and probability for the new mathematics curriculum under his supervision in the Colombian Ministry of Education. The first conceptual decision was to start, not from statistics and probability but from the handling of data systems. The reason for data systems is that the Colombian mathematics curriculum has a theoretical underpinning based on general systems. "Given any mathematical topic, the first challenge is to determine it in such a way that its components, its operations, and its relations become apparent. The main stress is on the transformations or operations, because they provide activity, dynamics to the system." (Vasco, 1994, p. 8-15).

To put into context the starting point for statistics and probability at any grade is provided by the real-life encounters students have with data systems. For example batting averages of their favourite teams, price of games in the shops and football scores to name but a few. Students find these data systems and investigate relationships among the data. The very same data analysis that is being introduced into North America but in a different format. Vasco (1994) goes on further to state;

Data systems have authors, and authors have purposes, interests, failures. Who built this data system? How good is their data? Should I trust the data, or is it better to check some of those numbers? What did they do it for? What else can I use it for? How can I make a summary of it for my purposes? What decisions could I support using this data system? (p 8-15).

The terminology may be different to that normally associated with data analysis but the outcomes expected are the same as in North America.

The Education Reform Act in 1988 became law and for the first time England and Wales had a statutory National Curriculum which represented a turning point in the history of education for these countries. The statutory curriculum for mathematics contained an attainment target called Data Handling. "Attainment target 5 - Handling Data: Pupils should collect, process and interpret data and should understand, estimate and use probabilities." (Sweetman, 1991).

Most countries in Europe already have a national curriculum and England and Wales are now following suit. There are differences in the way the curriculum is delivered most notably stated by Professor Burges (1996) "Maths in other continental countries is characterised by the teacher playing a central teaching role, not a management role as we so often see in the UK".(p. 1)

The Kassel Project, sponsored by the Gatsby Charitable Foundation, involves secondary pupils (age 13 plus) in 17 countries who have been taking tests in mathematics over the last 2 to 3 years. The countries involved include England, Scotland, Germany, Hungary, Poland, Singapore, Japan,

Thailand, Norway, Greece, Holland and Finland. This project has been looking to see how well pupils of similar ability in each country progress from year to year. The aim being to find the factors that give rise to enhanced progress and to make recommendations for mathematics teaching. The report highlights the differences in the way mathematics is delivered. Key areas between England and other European countries are:

1. The curriculum is more narrowly focused concentrating on 8 to 10 topics a year whereas in England 2 to 3 times this number is covered.
2. Continental text books allow for up to 6 times as much practice and consolidation.
3. Prescribed book list.
4. Calculators are not used till students are 13-14 years old.
5. Lessons are a joint venture which all participate rather than individualistic learning style.

For example the Swiss concentrate on getting the atmosphere right so that the class works as a community. The above points were found to be conducive to learning in mathematics particularly with data analysis techniques.

Developing countries rely "... heavily on text book material and still promote rote learning of definitions and formula rather than real understanding of statistical concepts. (Habibullah, 1995, p. 447). What EDA is taught depends on (a) the university which the schools feed into and (b) the enthusiasm of the teachers concerned. Bearing in mind that the teachers are not usually well paid and often have to take a second job to support their families.

In Croatia where Rozga (1993) stated:

The process of statistical education in Croatia can be considered to be as complex as it is in other developing countries. As part of former Yugoslavia, Croatia was a communist country with an inherited system of secondary and university education.... There is no uniform statistical education at the pre university level. A big problem is the lack of so called statistical culture or statistical literacy (p. 333).

There is obviously a great deal of help that is required if EDA is to be introduced into these countries.

In Pakistan a series of Statistics Teachers' Educational Program (STEP), provides "a forum for the enhancement of teachers' knowledge through participation in sessions containing (a) lectures by expert statisticians/professors, (b) open discussion and (c) group work regarding both course content and teaching methodology." (Habibullah, 1995, p.447). This country

has introduced data analysis techniques into its courses. Students have taken to the shift from rote learning to practical work with relative ease. The teachers have found the task more difficult and need supporting. Feedback from participants on the STEP have found this very useful and newer EDA techniques are now being investigated.

The pace of innovation has to be constantly monitored otherwise if it is too rapid teachers may be bewildered by new techniques and ideas behind them. The new developments are exciting and refreshing alter the more mechanical and repetitive calculations, with the emphasis placed on more practical exercises rather than abstract routines, there is a good chance that statistics will come to help the students in their ordinary life. (Starkings, 1993, p. 342).

### **When is data analysis introduced?**

When data analysis techniques are introduced to students varies from county to country. For example in Sweden and Spain primary school children are taught to use elementary techniques of data recognition to obtain information, and to represent it in graphical and numerical form. Students from Germany tend to start at the secondary level. Third world countries, like Pakistan, do not bring in EDA till later in the secondary curriculum and newer techniques such as stem and leaf or box plots are rarely covered, if at all.

There appears to be no consistent policy for introducing data analysis but developed countries do tend to cover the same material albeit at different ages. The approach taken for teaching data analysis is diverse due to the resources available, age of student and experience of the teacher. In developing countries resources are very limited and teaching is adapted. For example large data sets, collected by the students or given by the teacher, have all calculations and graphical representations done manually. There are few computers or calculators, if any, available. Finances to set up the Statistics Canada project would be virtually impossible. These developing countries rely on the developed world for support and guidance.

### **Summary**

Within the developed countries there appears to be a coming together of secondary school data analysis techniques. Many areas are such as stem and leaf or box plots are often ignored, even after several experts in the area have demonstrated, at various conferences, the benefit of including these topics. In third world countries, like Pakistan, the move towards the teaching and learning of data analysis techniques is prevalent.

The production of suitable textbooks, course material and computer software is becoming more widespread in developed countries with developing countries relying on the rest of the world for support. Holmes (1993) stated the following, which is still appropriate. "There is, though, a lot we can still learn from each and there are many ways in which we could be of mutual help".(p. 10)

To sum up the teaching of data analysis differs notably not only from continent to continent but between countries within the continents. What is worthy of observation is that data analysis techniques are becoming prominent within the mathematics curricula and relevant associated subjects. Terminology and language used is different, approach and teaching style varies, resources used are those that are available but the ultimate goal is the same.

What is meant by data analysis and that good procedures in data analysis involve techniques that help (a) to answer the substantive question at hand (b) squeeze all the relevant information out of the data and (c) learn something new about the world (Starkings, 1992, p. 104).

This is the ultimate aim of teachers throughout the world, irrespective of culture or creed.

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