# MEETING THE PERCEIVED NEEDS OF STATISTICAL EDUCATION WITH AVAILABLE TEACHING STAFF AND RESOURCES

Ann-Lee Wang
University of Malaya
Malaysia

*In recent years, responding to the demand of industry and other sectors of the economy, changes have been made both to the structure and curriculum of undergraduate degree programmes in University of Malaya. The Institute of Mathematical Sciences started to offer a separate B.Sc.(Stat) programme in the academic year 1996/97. Prior to this, only one degree, the B.Sc.(Math) degree, was awarded although students awarded this degree might have taken a large number of probability and statistics courses. Already the B.Sc.(Stat) degree programme has undergone several changes and more are being considered. This paper will describe the current state of the degree programme, discuss the changes already made and those being proposed, and compare the programme with the ASA Curriculum Guidelines for Undergraduate Programs in Statistical Sciences.*

## 1. INTRODUCTION

Malaysia is a developing country. In recent years, in response to the demands of industry and other sectors of the economy, and following the dictate of governmental policy, changes were made both to the structure and the curriculum of undergraduate programmes. Different universities in Malaysia responded differently to these demands. In this paper, only the B.Sc.(Stat) programme in University of Malaya will be discussed.

University of Malaya is the oldest university in Malaysia. The Department of Mathematics, established in 1959, had undergone a name change and is now called the Institute of Mathematical Sciences. It started to offer a new and separate statistics major programme, B.Sc.(Stat), degree course in the academic year 1996/97. Prior to this, only one degree, B.Sc.(Math) was awarded although students awarded this degree might have taken a large number of courses in probability and statistics. Already the B.Sc.(Stat) degree programme has undergone several changes since its inception and more are being comtemplated.

In Section 2 of this paper, the events and the evolution that had led to the current B.Sc. (Stat) programme in the Institute of Mathematical Sciences in University of Malaya will be discussed. In Section 3, a comparison of the B.Sc.(Stat) programme with the ASA Curriculum Guidelines for Undergraduate Program in Statistical Sciences is made. Some new developments are discussed in Section 4. In Section 5, some concluding remarks are made.

## 2. THE B.Sc.(Stat) DEGREE PROGRAMME

In the mid 1990s, a Ministry of Education directive decreed that all undergraduate degree programs, with the exception of the medical and dentistry programs, were to be three-year programs. This directive was issued at a time when Malaysia's economy was growing at a fast pace. There was a perceived need for trained staff. A shortened degree course would mean more graduates would be available to fill this growing need. So almost overnight a four-year B.Sc. degree in University of Malaya was reduced to a three-year program.

In conforming to the directive from the Ministry of Education, the staff in the Department of Mathematics deemed it an opportune time to offer five separate undergraduate degree courses instead of the existing three, namely B.Sc.(Math), B.Sc.Ed.(Math) and B.A.(Math). The new undergraduate degrees are B.Sc.(Math), B.Sc.(Industry and Computer), B.Sc.(Stat), B.Sc.Ed.(Math) and B.A.(Math).

Prior to the implementation of the new degree structures, a B.Sc.(Math) student was required to take some compulsory and some optional courses. The optional courses were to be chosen from a variety of optional courses in pure mathematics, applied mathematics and statistics. The new degree courses are modifications of this structure.

At the planning stage for the new B.Sc.(Stat) degree course, the majority of the statistics staff deemed it unnecessary to include Calculus III and Linear Algebra I in the compulsory

courses. However, in the initial implementation stage Calculus III and Linear Algebra I were included as compulsory courses. Other than the compulsory courses, students were in principle to choose some optional courses from a large number of probability and statistics courses. The first list of optional courses, as shown in Appendix A, contained nineteen Level III probability and statistics courses. In reality, the number of optional courses offered is limited by the availability of staff resources. There usually were hardly any choices due to a shortage in this area. For the academic year 2001/2002, the Level II and Level III optional courses are listed in Appendix C. Some Level III optional courses are continuation of Level II optional courses. Each optional course is offered only once per academic year. One exception to this rule occurred in 1999/2000 when Regression Analysis I was offered in both the semesters. The number of optional courses differed from year to year as shown in Table 1.

Table 1
*The Number of Optional Courses Offered for the Academic Years 1998/99 to 2001/2002*

| | 1998/99 | | 1999/2000 | | 2000/2001 | | 2001/2002 | |
|---|---|---|---|---|---|---|---|---|
| | Level II | Level III | Level II | Level III | Level II | Level III | Level II | Level III |
| Semester I | 2 | 3 | 1 | 4 | 2 | 4 | 3 | 2 |
| Semester II | 2 | 5 | 4 | 3 | 2 | 3 | 3 | 5 |

As can be seen from Table 1, in the academic year 1998/99, the first time Level III courses were run, three optional Level III statistics courses were offered in the first semester and five in the second semester. Subsequently, the number of optional courses and the topics for the optional courses changed from semester to semester and from year to year

Some of the courses in the original list of nineteen courses are now placed in the list of optional courses for the M.Sc.(Stat) by course work program. This program was run for the first time in 2000/01. Only nine students registered in the first semester. Five additional students registered in the second semester. Two students from this second intake dropped out in 2001/2 and three new students signed up in the first semester of 2001/02. One student graduated in 2001.

In the first three years, 1996/97 to 1998/99, aside from some compulsory non-statistics and non-mathematics courses, a B.Sc.(Stat) student had to take twenty-eight credits of compulsory courses and forty-five credits of probability and statistics optional courses. A one-credit course is equivalent to one hour per week per semester. A semester is assumed to be fifteen weeks in length. Most courses are either a two-credit or three-credit course. A three-credit course in theory amounts to thirty hours of lectures and fifteen hours of tutorials. In practice, twenty-six to thirty hours of lectures and twelve to fifteen hours of tutorials are given for a three-credit course. The twenty-eight credits of compulsory courses consisted of: (Calculus I, II and III), Linear Algebra I, Differential Equation and Application, Statistics, Introductory Probability, (Probability and Statistics I and II) and Further Mathematical Statistics. Among the optional courses is a course called Mathematical Science Project (three-credit course). So far three students had opted to do a statistics project under this course in 1998/99 and three students in 2000/01. There is also an optional course called Industrial Training. This course will not earn the students any points in the degree program.

A B.Sc. minor in statistics was also offered. There were no students enrolled for this program. In the academic year 1999/00, a course called Analysis of Data I, a two-credit course, was added to the list of compulsory courses for a B.Sc.(Stat) degree. The new degree structure was implemented in response to the demands of the industry sector, in abeyance to the directive from the Ministry of Education and to attract more students. The degree structure was intended to provide more and wider opportunities for undergraduates to specialize in areas that are related to industry. It was planned to be student-friendly and flexible allowing students to choose and arrange a program of study suitable to their needs and ability.

So after running the new degree structure for four years, a change was made in the degree structure in the academic year 2000/01 university-wide. Where the B.Sc.(Stat) program is

concerned, the course Further Mathematical Statistics was removed from the list of compulsory courses and placed in the list of optional courses. A new course called Introduction to Statistical Computing, a three-credit course was added to the compulsory courses. Linear Algebra II, a three-credit course was also added to the list of compulsory courses. Calculus I, II and III are each increased by one credit. So students have to take a total of twelve credit of Calculus.

Apart from other university requirements (non-statistics and non-mathematics courses), a B.Sc.(Stat) student is now required to take thirty-six credits of compulsory courses and thirty-seven credits of optional courses. The optional courses may be taken from a list of pure mathematics, applied mathematics and probability and statistics courses. These seventy-three credits are the core courses of the B.Sc.(Stat) program. Students may still choose to take further courses offered by the Institute of Mathematical Sciences for up to a maximum of another ten credits. A new course called Statistics Project, an eight credits course, is also included in the optional course. To date no student has taken this course. The Mathematics Science Project course is now a four credits course. Students wishing to take any of these two project courses have to come to a mutual agreement with a lecturer as to the topic of the project. This new structure is more streamlined. It is easier for students to comprehend the various requirements that would ensure that they obtained their degrees. There is no longer any provision for a minor in statistics.

In 2000/01, a new B.Sc. degree in actuary science was proposed and shelved temporary. Subsequently, in the following academic year 2001/02, two Level II courses called Financial Mathematics (three-credit course) and Life Contingency I (three-credit course) and one Level III course called Life Contingency II (three-credit course) were added to the list of optional courses. In July and August 2001 proposals for two new degree programs called B.Sc.(Financial Mathematics and Actuary) and B.Sc.(Operational Research and Applied Statistics) were put forward. No firm decision has been made yet as to whether these degree courses will be offered in the coming academic year 2002/03.

Other than the five first-degree programs, the Institute of Mathematical Sciences runs service courses for students from the Faculty of Science, the Faculty of Engineering, the Faculty of Computer Science and Information Technology and the Faculty of Medicine. The number of students in these service courses is usually very large in comparison to the number of students taking the degree courses in the Institute of Mathematical Sciences.

In the academic year 2000/01, the number of engineering students taught by staff of the Institute of Mathematical Sciences was 2430 and that of the Faculty of Computer Science and Information Technology was 1920. The enrollment for the compulsory statistics course for all non-biological science students in 2000/01 was 654. In contrast, the number of students taking B.Sc. degrees in the Institute of Mathematical Sciences is small. The first batch of graduates of the new degree structure, graduated in 1999, numbered only twenty-one students. These were all awarded the B.Sc.(Stat) degree. Four other students obtained the B.Sc (Physics/Stat) degree. There were no graduates from the B.Sc.(Math) and B.Sc.(Computer and Industry) programs.

After some intensive campaigning on the part of the applied mathematics staff and a restructuring of some of their courses, the following year there were twenty-one B.Sc.(Computer and Industry) graduates. In the same year, there were thirty-four B.Sc.(Stat) and two B.Sc.(Math) graduates. There was one B.Sc.(Chemistry/Stat) graduate. The number of graduates in subsequent years is expected to be higher for all the degree programs in the Institute of Mathematical Sciences. When the proposed B.Sc.(Financial Mathematics and Actuary) and B.Sc. (Operational Research and Applied Statistics) programs are implemented, it is envisaged that there will be less students taking the B.Sc.(Stat) programs. Some of the students who would have taken the B.Sc. (Stat) program would have decided to take one or other of these two new programs instead.

## 3. A COMPARISON

The statistical and mathematical topics covered by the courses in the B.Sc.(Stat) program more or less conformed to the ASA Curriculum Guidelines for Undergraduates Program in Statistical Sciences as shown in http://www.amstat.org/education/Curriculum_Guidelines.html. Some statistical topics in the ASA Guidelines that are not taught in the B.Sc.(Stat) program are: Bayseian methods, data mining and some aspects of design of studies. These topics are not taught

because the staff resources are not available to do so. Computing resources are also rather limited. Data mining may be taught at the postgraduate level. In the B.Sc.(Stat) program there is not much emphasis on connection between probability concepts and their applications in statistics. Most lecturers find there is just enough time to cover all the topics in each course.

Where computational skills are concerned, all students in the B.Sc.(Stat) program are taught how to use the Student's version of MINITAB. The new compulsory Level II course, Introduction to Statistical Computation, introduces the JAVA language. Students are taught to use this language to perform statistical computation. For teaching purposes, there is enough hardware for S-plus to be used only on twenty machines concurrently. So some students in smaller classes may also be taught to use the S-Plus. The computational skills taught fall short of those envisaged in the ASA Guidelines.

There is no course in "non-mathematical topics" in the B.Sc.(Stat) program. A Vice Chancellor's directive in April 2001 has directed that some move to run courses on "proficiency in thinking and communication" should be considered and be included in all first-degree programs in University of Malaya. At the moment students doing a Mathematical Science Project will be guided to write clearly and speak fluently. However, only a few students take this project course in any one year. Teamwork, as described in the ASA Guidelines, has so far not been incorporated into the project course. Students in the B.Sc.(Stat) are not taught consulting skills. Some students may take part in industrial training. This training is not taken into account in the awarding of a B.Sc.(Stat) degree.

There is no "capstone" course as recommended by ASA Guidelines. In the two Data Analysis courses students learned some basic skills in data analysis. Student practice data analysis using data obtained from a variety of statistical texts such as those by Siegel and Morgan (1988), Chambers, Cleveland, Kleiner and Tukey (1983) and Kitchens (1998). There is no course in any "substantive area" and none has been planned. Students in the B.Sc.(Stat) programs may take some introductory courses in other disciplines in the university as part of faculty or university requirement. Such courses do not amount to a "substantive" knowledge of a particular discipline.

The B.Sc.(Stat) program provides an adequate education for the students within the constraint of the framework of a first degree course in University of Malaya. There appears to be some room for improvement for the program in terms of courses taught and the content of each course. Certain ideas from the ASA Guidelines may be incorporated into the program. Certainly, non-mathematical skills such as communication and writing skills need to be taught as can be seen in the directive from the Vice Chancellor described in the following section, Section 4.

Culturally, the educational system in Malaysia has instilled the habit of learning by rote in students prior to their entry to university. The majority of students seem to prefer the "spoon-feeding" approach to learning a topic. Some planning has to be done to ensure that students acquire some analytical skills. In the present system students are taught a variety of statistical tools that they vaguely grasp and are usually unable to apply their knowledge to new situations. The Projects courses at the moment are not very popular. A capstone course would be far better than the present Project courses. A student would learn more and in a more systematic manner from a capstone rather than from personal supervision on a particular project.

The amount of mathematics and the time sequence in which the topics are taught have to be arranged more consistently. At the moment, when certain calculus methods are required in a statistics course, it is usually found that the methods have not been taught yet in the calculus course. It can be seen from Table 1 that optional courses are run dependent on the availability of staff. There is a need to increase staff resources in the Institute. Computing resources also need to be increased.

## 4. SOME NEW DEVELOPMENTS

Following a directive from the Vice Chancellor of the university in April 2001, all undergraduate programs will be revised with the following objectives:

1. To ensure that graduates are proficient in identifying and solving problems,
2. To ensure that graduates are able to communicate effectively in Malay (the Malaysian national language) and English,
3. To ensure that graduates have professional ethics and morals,

4. To identify programs that need to be restructured or revised according to the needs of the market place,
5. To upgrade the syllabus, methods of teaching and method of evaluation of students in order that graduates will meet the needs of future employers.
   The main concern is to ensure that graduates are proficient in the use of their knowledge.

## 5. CONCLUDING REMARKS

The curriculum of the B.Sc.(Stat) programme is constantly being revised. The evolution of the curriculum is based on demands of market forces, Ministry of Education and the Vice Chancellor's directives. The B.Sc.(Stat) programme is run within these constraints and with the existing available resources. The program ensures that students learn some mathematics and some statistical tools. It is possible for students to avoid learning much probability. They can do so by not taking optional courses in stochastic processes.

## REFERENCES

Chambers, J. M., Cleveland, W. S., Kleiner, B., & Tukey, P. A. (1983). *Graphical methods for data analysis.* Boston: Duxbury Press.

Kitchens, L.J. (1998) *Exploring Statistics* (2nd edn.). Pacific Grove, Calif.: Duxbury Press.

Siegel, A.F., & Morgan, C.J. (1988). *Statistics and data analysis: An introduction*. New York: Wiley.

## APPENDIX A

The first list of optional courses (each of which is a three-credit course) proposed

*Level II*

Linear Algebra II, Numerical Methods, Stochastic Processes, Data Analysis II, Regression Analysis I, Non-parametric Statistics

*Level III*

Branching Processes and Renewal Theory, Stochastic Models, Applied Stochastic models, Monte Carlo Simulation Methods, Risk Theory, Reliability Theory, Information Processing and Statistical Communication Theory, Statistical Decisions, Multivariate Analysis, Design and Analysis of Experiments, Response Surface Methodology, Survey Sampling, Statistical Quality Control, Applied Decisions, Statistical Computation, Time Series Analysis and Forecasting, Discrete Data Analysis, Life Data Analysis, Robust Statistics

## APPENDIX B

Core compulsory courses for the current (2001/02 session) B.Sc.(Stat) programme.
(The number of credits for each course is indicated in brackets after the course name.)
Linear Algebra I (3), Linear Algebra II (3), Calculus I (4), Calculus II (4), Calculus III (4), Differential Equation and Applications (2), Data Analysis I (2), Statistics (3), Introduction to Probability (2), Probability and Statistics I (3), Probability and Statistics II (3), Introduction to Statistical Computing (3).

## APPENDIX C

Optional statistics courses in the core B.Sc.(Stat) programme offered in the academic year 2001/02. (All courses are three-credit courses.)

*Level II:* Financial Mathematics, Stochastic Processes, Data Analysis II, Regression Analysis I, Non-parametric Statistics, Life Contingency I.

*Level III*: Introduction to Multivariate Analysis, Design and Analysis of Experiments, Regression Analysis II, Introduction to Survey Sampling, Statistical Quality Control, Life Contingency II, Introduction to Reliability Theory.

## APPENDIX D

The following optional courses can be taken by mutual agreement between student and lecturer. Statistics Project (8 credits), Mathematical Science Project (4 credits)

## APPENDIX E

Students may also take part in Industrial Training (3 credits). This course does not count towards points for the B.Sc.(Stat) degree.