Teaching operational research/management science in higher education: distance learning study units for new or current teachers

Ian Cooper
Consultant to RSSCE
ianc@adslcooper.plus.com

For several years the statistics team of the UK Higher Education Academy (HEA) Mathematics, Statistics and Operational Research Network (MSOR Network) has successfully run the course Certificate in Teaching Statistics in Higher Education, fully accredited as a Certificate qualification by the Royal Statistical Society [1]. A distinctive feature of the distance learning material that constitutes the core of this course is its flexibility. It may be used as a (possibly optional) unit in a university PgCert or Diploma in Teaching and Learning. Alternatively, the individual units may be used as distance learning components in both initial training (induction) courses and continuing professional development programmes.

The MSOR Network also supported the development of an Associate Module entitled Teaching Mathematics in Higher Education, which was accredited by the University of Birmingham, where an annual induction course for lecturers new to teaching mathematics and statistics in HE also takes place [2].

With successful courses in both mathematics and statistics thus firmly established, attention has recently turned to the ‘missing’ component in the provision of MSOR Network teaching support for HE, namely operational research (OR).

Clearly, there are overlaps in terms of pedagogy and good practice across all three of the Network’s eponymous academic areas. However, the characteristics of OR - its unique nature as a discipline, its close ties to business, its many domains of application and the range of levels at which it can be taught within HE - do give rise to special challenges for the OR teacher.

To assist in meeting these challenges (and to complete the MSOR Network subject circle) a suite of distance learning units in operational research/management science (OR/MS) has been developed. The full set of new units allows flexible study modes up to and including PgCert.

The name OR/MS was chosen to reflect the enduring popularity of each of operational research and management science in HE undergraduate and postgraduate course titles, and it also recognises the international adoption of the subject name OR/MS in both the academic and the professional spheres.

This article gives the rationale behind the course structure and summarises the content of the component units.
Background

From its peak of popularity in the late 1980s to mid 1990s, OR, as a subject to study at university, has had mixed fortunes. Following a decline in the late 1990s, it is pleasing to find that there has been a consolidation of numbers from the year 2001. Several reasons could be given for this but it appears that at the undergraduate level the popularity of OR has largely mirrored that of mathematics over recent years. The sterling efforts of the MSOR Network, the universities and the professional bodies on behalf of mathematics seem to have had a spin-off to the benefit of OR. Meanwhile, at the postgraduate level, OR course provision and consequent take up have been commendably resilient in the face of a tightening funding climate in universities.

Table 1: Students studying OR in UK HE institutions (2000/01 to 2007/08)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TOTAL IN UK HE</th>
<th>FUL-TIME UG</th>
<th>FULL-TIME PG</th>
<th>PART-TIME UG</th>
<th>PART-TIME PG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008</td>
<td>855</td>
<td>415</td>
<td>355</td>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>2006/2007</td>
<td>800</td>
<td>315</td>
<td>350</td>
<td>5</td>
<td>130</td>
</tr>
<tr>
<td>2005/2006</td>
<td>815</td>
<td>325</td>
<td>350</td>
<td>5</td>
<td>135</td>
</tr>
<tr>
<td>2004/2005</td>
<td>965</td>
<td>410</td>
<td>385</td>
<td>5</td>
<td>165</td>
</tr>
<tr>
<td>2003/2004</td>
<td>1190</td>
<td>575</td>
<td>365</td>
<td>65</td>
<td>185</td>
</tr>
<tr>
<td>2002/2003</td>
<td>815</td>
<td>430</td>
<td>200</td>
<td>50</td>
<td>135</td>
</tr>
<tr>
<td>2001/2002</td>
<td>820</td>
<td>350</td>
<td>250</td>
<td>30</td>
<td>190</td>
</tr>
<tr>
<td>2000/2001</td>
<td>505</td>
<td>185</td>
<td>185</td>
<td>0</td>
<td>135</td>
</tr>
</tbody>
</table>


(Note that the above numbers apply only to named OR/MS courses. Many more students do study the topic as a unit within their degree programme)

Not only the universities were concerned at the decline in OR numbers around ten years ago, but so were the industrial, commercial and public sector employers of graduates and postgraduates in the subject. It was time for action!

Rather belatedly, the main UK professional body, the OR Society, began to co-ordinate activities involving schools, universities and industrial users of OR, in an attempt to reverse its decline in fortunes. Work began with an ‘OR Visioning’ initiative in 2003, which resulted in a prime aim to achieve a higher profile for OR in all of the three areas of concern, namely school, university and industry.

The OR Society commissioned a report that examined the implicit ‘supply chain’ of recruits to the OR profession [3]. Overall it was found that a confusing image of OR persisted throughout, and the more specific findings can be summarised as:

- there was a lack of OR visibility in schools;
- fewer were seeing OR as a degree choice;
- fewer first degree courses with an OR flavour were being offered;
- fewer were seeing OR as a career or higher degree option;
- there were problems in the recruitment of good OR academic staff;
- universities were becoming less supportive to the development of OR in general or to OR teaching across other disciplines; and,
- there was a lack of general commitment to OR continuous professional development in universities.

Since then, it is pleasing to note that significant progress has been made in addressing these points, to the benefit of each of the stages identified in the supply chain:

The OR Society began the action by setting up a ‘Schools Task Force’ to make things happen at the ‘front end’. It had the ambitious stretch target: Every school pupil should know what OR is.

With support from COPIOR (the committee of professors in OR) and the MSOR Network, funding was obtained from ORS to appoint a project officer to develop modern teaching and promotional materials in schools, aimed at pupils from as young as 11+ right up to those taking the decision mathematics module at A-level. Examples of teaching support materials in typical topics such as travelling salesman, bin packing, linear programming, CPA etc. may be viewed at the dedicated website [13]: http://www.learnaboutor.co.uk.

An innovative careers DVD for use in schools has also been produced by the ORS.

For university students, both academics and employers have contributed to the provision of in-depth guides to practical OR and to case studies [4], and numerous classic examples of OR theory, practice and education have been made freely available [5]. In addition, a leaflet drawing together the key OR techniques and formulae will shortly be available from MSOR Network [6].

The MSOR Network has also contributed OR/MS resource references for new HE teachers via the SNAS (Supporting New Academic Staff) database [7].

The ORS has commendably become ever more pro-active in universities and industry, having recently produced publicity material for distribution by its members in both these areas of OR activity. Executives are also widely encouraged to explore the theme of Operational Research: The Science of Better, to learn how OR can contribute to better decisions at strategic and operational levels in virtually every kind of organisation [8].
Future supply and demand

The Joint Council for Qualifications (JCQ) has reported a continued up trend for mathematics and further mathematics A levels in 2009 and an enduring support for decision mathematics [9]. It is to be hoped that, once aware of the benefits of a career in OR, an increasing proportion of mathematics pupils will consider an undergraduate course in OR at university. Likewise, better awareness within universities and organisations should promote an increased interest in postgraduate OR courses and careers in the OR profession.

In terms of current provision, the ORS website http://www.theorsociety.org [14] recognises around 28 universities offering ‘named’ OR/MS undergraduate and postgraduate courses. The Universities and Colleges Admissions Council (UCAS) lists over 70 undergraduate programmes that feature OR/MS (or variants such as business analysis, business modelling, business analytics, decision sciences etc.) for 2010 entrants [10].

Evidence from specialised publications such as Inside OR (ORS) suggests that job prospects remain excellent, for both new graduates and for experienced OR professionals. The transferable skills of OR are in demand by organisations operating in such areas as health, government, finance, energy, manufacturing, retailing, transport and travel, mining and telecoms.

Moreover, all of this implies that a good number of OR/MS university teachers will still be needed in future to deliver their courses in a relevant and supportive way.

Teaching OR/MS in Higher Education – course development and structure

In a recent paper Molinero and Xie [11] undertook to ascertain just what UK employers want from OR/MS graduates and what this could mean for the content of OR/MS degrees. They point out that job advertisements in the specialised press are almost a ‘cry for help’ to teaching institutions, as employers indicate the skills they require and the contexts in which they can be applied. They conclude that employers are increasingly seeking recruits with the technical ability to analyse large data sets and the ability to communicate the results. In university courses a shift away from mathematical rigour (and the quest for optimality) and more emphasis on the analysis of real data are recommended.

A consequence of such evolution (revolution?) is that university OR/MS teachers do need to keep in touch with the requirements of employers and to continue their own professional development if they are to make the student learning experience in OR/MS both relevant and valuable. And new teachers need to be introduced to the special nature of OR/MS teaching in HE, characterised by its theoretical and practical content, its varying depth and range across different degree programmes, and its strong technological and business connections.

Early thoughts about what type of course should be provided by the MSOR Network for HE teachers in OR/MS centred on the two existing provisions - in mathematics and in statistics.

Potential HE teacher candidate numbers had to be an important consideration. Although there is a continuing requirement for professional development of both ‘dedicated’ and ‘part-time’ OR/MS lecturers, they are likely to remain fewer in number than, say, mathematics teachers in HE.

Following consultation it was generally agreed by both academics and staff developers that the most appropriate model for OR/MS was that used already for the MSORN/RSS Certificate in Teaching Statistics in HE. The course has a track record of student acceptability and also benefits from a high academic and professional standing. It consists of a set of distance learning course units, flexible enough to be used in a variety of ways.

This property of flexibility has been built into the newly developed OR/MS course described below.

Teaching OR/MS in Higher Education – course aims and content

The Induction/Certificate course in OR/MS teaching aims to enable candidates from a variety of academic and/or professional backgrounds to develop understanding and skills that will help them to be competent and professional teachers of OR/MS in HE. These skills will enable them to contribute to the teaching of their subject at a high level and to gain the ability to learn by experience from their own environments.

The course has two main ways of achieving its aims, namely through the course material and through the assessment. The assessment is not just a test of the understanding of the material. It is a fundamental part of the achievement of the aims of the course.

The HEA sees the university teacher’s role as having six components, which in summary are

- design and planning of learning activity;
- teaching and the support of student learning;
- assessment and feedback;
- developing learning environments and student support;
- integration of scholarship, research and professional activities with teaching and supporting learning; and,
- evaluation of practice and continuing professional development.
With this framework in mind the course focuses on the teaching of OR/MS rather than on the well known OR/MS methods and techniques themselves.

The distance learning material that addresses the six components in a manner beneficial to the OR/MS teacher is presented in five units. Numerous examples from experienced OR/MS teachers are given in each unit, along with copious exercises aimed at consolidating understanding. Substantial references and resource guides are also provided. The aims of each unit and indicative contents are given below:

1. Teaching OR/MS in HE – A Guide to the World of the OR/MS Teacher in HE and Introduction to the Induction/Certificate Programme

The aim of this unit is to introduce our view of the world of OR/MS and to examine the position in this world of the OR/MS lecturer (teacher) in HE, with special reference to the UK. OR/MS can be taken to include operations research, decision methods, business analysis and similar names by which our subject is known and taught.

The term ‘teacher’ is preferred because it is felt that the traditional name ‘lecturer’ implies, in general, too narrow a job title for what is needed to enable students to understand, learn and retain a body of knowledge and skills in OR/MS. The modern pressures on HE teachers are great, but even for those already established in HE, it will pay to look beyond their own current teaching. This unit gives useful guidance to the HE teacher, for whenever the opportunity may arise to take a broader look at their role in the world of OR/MS. It includes:

• Some Statistics of OR/MS in HE;
• The History of HE Courses in OR/MS;
• The Environment of OR/MS in Higher Education;
• The Community of OR/MS Academics;
• The Foundations at School and at College;
• A Career in OR/MS;
• Values and Ethics;
• Professional and Legal Requirements;
• Teachers of OR/MS in Other Specialist Departments; and,
• Diversity and Opportunity.

2. Aspects of Teaching OR/MS in HE

The aim of this unit is to help relate the generic aspects of teaching and learning that may have been studied elsewhere to a specific, subject based, appreciation of the elements and methods of OR/MS teaching. From being aware of these connections and other contributory factors teachers will learn from the unit how to select appropriate teaching methods for a given course and how to design and deliver (at a variety of levels) the different elements of a course in OR/MS. It includes:

• The OR/MS Course;
• The OR/MS Curriculum;
• The Student of OR/MS;
• The Student of OR/MS;
• The Teacher of OR/MS;
• Explaining the Nature of OR/MS;
• Teaching Methods for OR/MS – General;
• Choosing an Approach to Teaching OR/MS; and,
• The Teaching Environment.

3. Teaching Specific Topics of OR/MS in HE

This unit builds on the more general aspects featured in the previous unit. There is a detailed look at the more specific aspects of teaching common topics in OR/MS, and the associated educational issues are examined. For instance, gauging the amount of mathematics and statistics involved (as prior knowledge or as additional input) to ‘service’ courses and indeed to ‘specialist mathematics’ degree programmes is discussed.

The traditional OR/MS topic focus comes in two illustrative sections that discuss specific issues and ideas for teaching the ubiquitous topics of queuing/simulation and mathematical programming/optimisation.

By following the arguments and ideas presented in these key topic areas it is hoped that the teacher will be able to devise their own methods and approaches for any of the other topics that appear on an OR/MS syllabus, now or in the future. The comprehensive resource list and set of specific references assist in further engagement with teaching, research and pedagogy in OR/MS. It includes:

• Teaching Service Courses;
• Teaching OR/MS within Mathematics Degrees;
• Teaching Statistical Techniques to OR/MS students;
• Teaching Mathematical Programming/Optimisation;
• Teaching Queuing/Simulation;
• Research and Consultancy; and,
• Teaching a Developing Subject.

4. Assessment and Feedback in OR/MS Teaching in HE

This unit evaluates the different types and purposes of assessment strategies within OR/MS courses. What are we assessing and why? And how best to do it within the
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constraints of the overall course, and the university’s quality assurance framework? Specific issues for OR/MS teachers, such as assessing model construction and dealing with IT based assignments are considered. Satisfactory feedback to students is both valuable and essential. Different approaches to managing feedback are investigated. It includes:

- Types and Purposes of Assessment;
- What are we assessing?
- Formative Assessment;
- Feedback;
- Summative Assessment;
- Techniques and Practicalities – Formative and Summative;
- Two Principles and Four Aphorisms;
- Specific Methods of Assessment in OR/MS;
- Assessment of Active Learning Approaches;
- On Marking;
- The Use of Statistics in Assessment; and
- OR/MS Course Evaluation.

5. Learning OR/MS

The theme of this unit is: Learning by the student, by the class, via the teacher. The teacher will probably have encountered some of the general theories of learning before studying this course. It would no doubt be useful to follow this up by introducing an agreed theory of how students learn OR/MS. Unfortunately such a theory does not exist. It even may be that a single theory is not entirely appropriate in such a widely applicable discipline as OR/MS. However, some aspects of the OR/MS methodology and exposure to its set of transferable skills will almost always form the basis of the curriculum to be learned and delivered, bringing new learning challenges for the student, and new teaching challenges for the teacher. In order to support these challenges, the unit makes reference to selected elements of learning theory, associated with supporting evidence, and to numerous anecdotal stories and experiences relevant to OR/MS teaching in HE.

The topics of the unit yield a number of learning insights that the theory suggests. These are grouped according to their particular relevance to learning - by the student, or by the class - via the teacher. For each learning insight there is an exploration of the ways in which it leads to relevant applications for the learning of OR/MS. It includes:

- The Student Learning OR/MS;
- The Class Learning OR/MS; and,
- The Lecturer Teaching OR/MS.

Teaching OR/MS in Higher Education – study and assessment

The Certificate course material and the assessment are both aimed at achieving a specific set of learning objectives based on the six HEA components outlined previously. The overall course philosophy requires candidates to:

“Assess, select, combine, use and reflect on appropriate aspects of learning theory in the planning, design and development of learning and teaching materials and methods for the teaching of OR/MS in HE.”

The five units of the course are presented in printed booklets, each containing numerous references and links to supplementary source material. A feature of the approach is the use of on-line sources and exercises in connection with the learning and teaching of OR/MS methods, techniques and applications.

The Certificate course is assessed on the basis of a portfolio, whose main component is a collection of developmental material designed for a module that the participant on the course is teaching, or intends to teach.

The course material provides the initial set of ideas. The assessment requires candidates to show that they can work with these ideas and develop relevant skills in their own teaching and learning contexts, as indicated in the portfolio guidance shown below:

1. Analyse a problem in your own teaching: set yourself a personal learning objective related to the problem; research the problem; develop appropriate solutions and the corresponding teaching and learning strategies and materials. Critically evaluate the outcomes. The personal learning objective is for you to achieve while pursuing the Certificate course, it is NOT an objective set for your students.

2. Analyse and evaluate your teaching using appropriate educational frameworks and models and record the experience in your professional personal diary in the portfolio.

3. Communicate effectively the outcomes of your studies in the appropriate written form, via the portfolio.

(the individual learning objective could relate to the context of an aspect of OR/MS, a specific teaching method or active learning approach, or to some specific group of students)
Where the full Certificate diet is not appropriate for certain individual candidates or institutions, the first four units described above can be combined to form an OR/MS subject based induction course.

HE institution staff development units may choose to include selected subject units in combination with generic teaching and learning studies in a programme leading to their own PgCert/Diploma in Learning and Teaching qualification.

Alternatively, individual units may be utilised on a self-study basis within a continuous professional development context, supporting ‘on-the-job’ OR/MS teaching experience.

Thus for both new and experienced HE teachers, MSOR Network can now offer appropriate staff development opportunities in OR/MS that are designed to complement the Network’s well-established provision in mathematics and statistics.

References


2. Learning and Teaching in Higher Education: Mathematics (Please note: this has now been superseded by the generic teaching and learning modules). Available via: http://www.hr.bham.ac.uk/development/courses/landt/ [Accessed 11 January 2010].


