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## The use of case studies in OR teaching

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### ABSTRACT

This article investigates the current use of case studies in the teaching of Operational Research (OR) in the UK: how and where they are used; how they are developed; and whether there is an interest in training this area. It is aimed at lecturers teaching OR who are using or planning to use case studies in their teaching. It may also be of interest to policy-makers who wish to know what is being done in OR. The article focuses on the results of a survey sent to lecturers of OR in higher education in the UK. These are combined with an examination of the literature on using case studies in teaching in general and a small number of specific examples of how case studies are used in OR teaching. Case studies are included in OR teaching in a variety of ways and to develop a range of skills; particularly the ability to transfer academic knowledge to real-life contexts. The article identifies that the most significant barrier to the use of case studies in OR teaching is the development of new case studies; suggestions are made to address this, including providing training and collaboration opportunities. Overall this article provides an assessment of the ways in which case studies are used in OR; the advantages and limitations of using them; and specific examples of their use which will provide ideas to assist in improving OR teaching.

### KEYWORDS

Operational research; case studies

## 1. Introduction

Over a hundred years ago when Harvard Business School initiated a case study method of teaching this was a novel approach (Herreid, 2011). Since then the analysis of real world cases has become a standard teaching method in business, law and medical schools (Herreid, 2011; Stanford University, 1994).

For this work, a case study is defined to be a substantial problem based on a real-life example or designed to be similar to the types of problem that occur in real life. Such problems can be used as examples in lectures (or other teaching environments) or as problems that students work on either individually or in groups, and may or may not be assessed.

The OR Society (2013) defines Operational Research (OR) as:

the discipline of applying advanced analytical methods to help make better decisions.

OR includes a range of mathematical and problem-structuring techniques, which can be used to improve decision-making such as: Mathematical Programming, Simulation, Forecasting, Algorithms, Decision Analysis and Cognitive Mapping.

In the UK, OR is taught predominantly in Business and Management or Mathematics programmes, particularly at M.Sc. level. Aspects of OR are also covered in other disciplines such as Engineering, Computer Science and Geography. Within secondary education, OR is included in the syllabus of Mathematics AS and A Level in England, but is not included in the specification for Scottish Higher Mathematics (Scottish Qualifications Authority [SQA], 2010). Programmes in OR, particularly the M.Sc. programmes are often seen as a good route into a future career as an OR practitioner. Consequently, students expect to be taught the methods, models and frameworks of OR within an applied context.

Outside of the formal school and university system, OR is taught by the UK professional society, the UK OR Society, which runs an annual training programme. Events are also provided at professional conferences in the form of specialist tutorial sessions.

Sodhi and Son's (2008) exploration of the skills requested in adverts for OR-related jobs in the USA identified that in contrast to many management programmes many OR programmes lack 'the development of "soft" skills – *communication, leadership, team-related skills* – that are invaluable for *improving operations and business processes*'. These are skills that can be developed by teaching with case studies.

The article continues with a description of the methods used in Section 2. A detailed discussion of the results is given in Section 3, the main points of which are summarised in the Conclusion.

## 2. Method

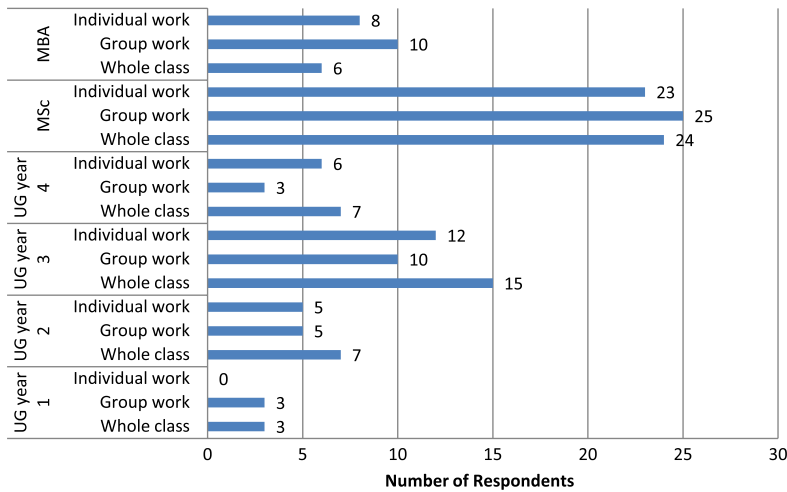
The project was split into three parts:

- (1) Review of the existing literature on the use of case studies in OR teaching.
- (2) An anonymous online survey of people teaching OR in UK universities.
- (3) Detailed interviews with individuals who use case studies in their teaching.

A search was carried out with search terms: case studies and OR. As the number of papers describing the use of case studies in OR was limited (Bell & von Lanzanauer, 2000; Cochran, 2000; Robinson et al., 2003), the search was widened to include more general reports about their use.

The online survey was conducted to assess the current use of case studies in OR teaching and the desire for future collaboration and/or training in the design of new OR case studies. Specifically, the questions that the survey aimed to answer were as follows:

- (1) to assess how widespread the use of case studies is in OR teaching in the UK;
- (2) to determine which skills case studies are used to develop/assess;
- (3) to identify implications from the advantages and limitations of case studies for consideration in planning teaching using them;
- (4) to identify examples of what makes for effective teaching with case studies;
- (5) to determine if there is demand for training on the use of case studies in OR teaching.



**Figure 1.** Responses showing the cohorts with which respondents use case studies and the ways in which students work on the case studies – UG is short for undergraduate: results from the online survey.

A total of 305 individuals from 76 UK universities were contacted, based on academic membership of the OR Society or identification of the lecturers for OR-related modules via university websites. A link to the anonymous survey was sent out by email to those identified. It was available for 19 days and a reminder was sent out to those who had not responded halfway through that time period. In total, 82 individuals from 37 different universities responded, either by completing the survey or by telling us that they either do not teach OR or do not use case studies, i.e. a response rate of 26.9% for individuals, covering 48.7% of the universities contacted. Removing those respondents who either do not teach OR or do not use case studies in their teaching left 53 respondents, whose answers are analysed below. The respondents included individuals from English, Welsh and Scottish institutions. The majority of the respondents are based in Management groups within their universities, with others based in Mathematics or Computer Science groups.

As part of the survey, individuals were asked if they were willing to be contacted to discuss the research in more depth. Of those who agreed, we arranged interviews with a selection who were chosen to provide a wide range of examples of ways in which case studies are used in OR teaching. These interviews were conducted by telephone. They involved discussion of the benefits and issues associated with offering particular types of case studies, without revealing any information that would be of use to a student being assessed on them. The resulting examples are included in the next section.

### 3. Analysis

This section brings together all of the information gathered throughout the study to address the five points raised in the Section 2.

### 3.1. Spread of use of case studies in OR teaching

This section explores the variety of programmes and modules in which case studies are used in OR teaching as well as the teaching contexts in which they are used and assessed.

Amongst the survey respondents who teach OR, 36 are based on Management groups within universities, 8 in Mathematics groups, with a further 4 teaching both Management and Mathematics, and 5 teaching Computer Science.

Amongst respondents case studies are used with a wide range of students, with the case studies used in a mixture of whole class, group work and individual projects, as shown in Figure 1. The greater use of case studies in the teaching of OR to M.Sc. students and third year undergraduates reflects a concentration of OR teaching at these levels.

This reflects the variety of different formats in which case studies are used across the curriculum in higher education that the pedagogic literature identifies:

- lecture: description of a case, perhaps using a student response system to check the students' understanding (e.g. Herreid, 2009);
- discussion session: whole class discussion of a case study (e.g. Herreid, 2009);
- small-group work: discussion of cases in small groups (e.g. Herreid, 2009);
- individual cases: students analyse the case and write it up individually (e.g. Herreid, 2009);
- interrupted case method: students are given part of the information about a problem and asked to consider how they proceed and then consider how this changes as further information is given (e.g. Herreid, 2005);
- computer simulation: students' analyses of the case are supported by a computer simulation (e.g. Graham, Morecroft, Senge, & Sterman, 1992).

The selection of the most appropriate type of case to use will depend on the learning objectives of the module, although it is worth noting here that Herreid (2011) considers small-group cases to be the best for student retention of learning, followed by individual cases, with lecture-based cases faring worst for this factor.

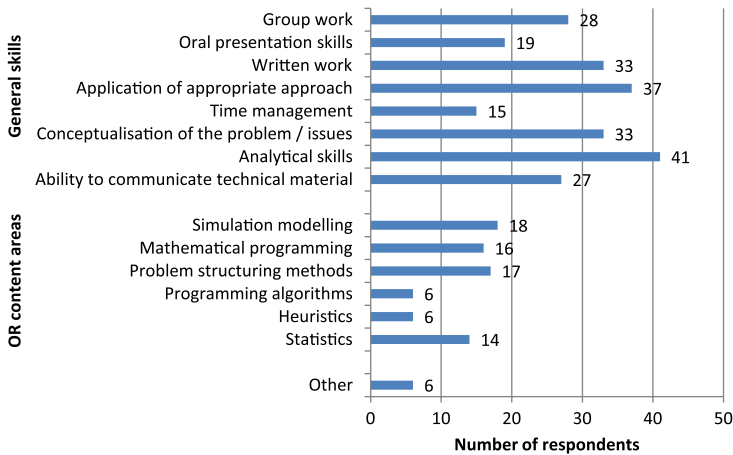
Where they are used in assessed work, the survey results show that case studies most often form part of coursework assignments, being almost equally likely to form the entire assessment for a module as part of it. There are also a few cases where case studies form part of an examination; example A demonstrates how the practical skills developed by working on case studies can be tested by students working on a further case study during the examination.

#### **Example A: Case Studies in Examinations at Lancaster University Management School**

**Provided by: Professor Graham Rand**

In this example, a significant part of the assessment takes the form of an examination.

The students are prepared for this by working through a series of group work case studies, which they work on over 1–3 weeks. These case studies are assessed based on the presentations and reports, providing students with feedback as they work towards the final examination.



**Figure 2.** The variety of skills which are assessed using case studies: results from the online survey.

For the examination itself, students have 4 h to work on an unseen case study, reduced from a previous duration of 7 h. This is a significant amount of time to spend on one problem, allowing students time to work on a substantial issue.

The particular advantages of assessing case study work by examination are: significantly reducing the potential for plagiarism, avoiding the issues that can arise with group work, such as some students not pulling their weight within a group, but still getting the same mark; and the danger of some groups spending too much time on the problem to the detriment of work for other modules. The main challenge is that they are a “tough task to mark”, particularly since they are open-ended tasks. This is addressed by double blind marking of a substantial sample, in order to calibrate the marks, which has workload implications.

The survey results also show that where a case study does not form part of an assessment the same case study is likely to be used several times, either in repeats in different years or with different cohorts in the same year. Where they are used as part of an assessment they are equally likely to be used in consecutive years or alternate years, with a slightly lower number only using each case study once for assessment. Repeated use of the same case studies allows them to be improved based on students’ reaction to them in previous years, but could create opportunities for plagiarism between year groups.

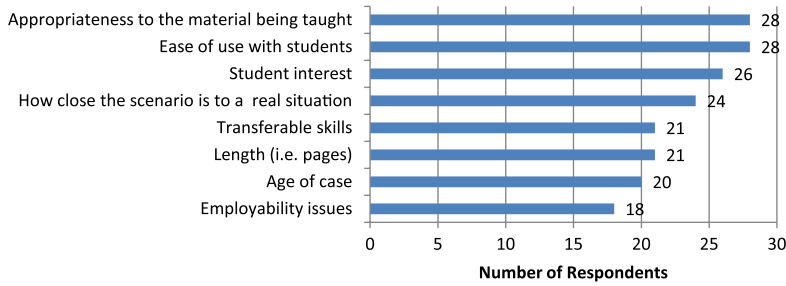
The results demonstrate that case studies are being used in OR teaching in a variety of contexts and with a range of teaching and assessment methods. This suggests that the use of case studies can be adapted to assess or develop a range of skills.

### 3.2. Assessing skills

A wide range of skills are assessed using case studies, including both subject specific and general skills, as demonstrated by the survey results shown in Figure 2.

These correspond well with the reasons to use case studies described in the literature:

- bridging the gap between theoretical concepts and practical experience (Cochran, 2000; Hassall, Lewis, & Broadbent, 1998; Hershey & Walker, 2006; Stewart & Dougherty, 1993);



**Figure 3.** The factors respondents consider important in selecting new case studies: results from the online survey.

- developing students' higher order critical thinking and analysis skills (Hassall et al., 1998; Herreid, 2011; Hershey & Walker, 2006; Stanford University, 1994; Swanson & Morrison, 2010; Yadav et al., 2007);
- developing skills such as teamworking, oral and written communication (Hassall et al., 1998; Stewart & Dougherty, 1993);
- developing students' ability to view an issue from multiple perspectives and to address ethical issues (Herreid, 2011; Yadav et al., 2007).

In selecting appropriate problems for developing into case studies for use in teaching a variety of factors are considered important, as can be seen in the survey results shown in Figure 3.

Case studies can be used throughout a module to allow students to learn through problem-based learning as demonstrated in example B.

### **Example B: Case Studies for Problem-Based Learning at Manchester Business School**

**Provided by: Dr Nathan Proudlove**

Individual mini case studies are used within class on core units of the M.Sc. programme. Sessions are long (3 h) and split equally between case studies, theory and examples. Students are asked to bring laptops to the teaching sessions to allow them to work on the cases. Usually, students will sit in groups and support each other. As the ratio of lecturer to student is approximately 1 to 60, the module lecturer can provide very little individual support during these sessions.

Case studies work well on this programme because it is heavily biased towards application, with the emphasis being on the students being able to solve problem and use state-of-the-art software. In this sense, the case studies fit excellently with the learning objectives. In-class cases are modified as little as possible from real life, and the best cases come from real projects, especially where the lecturer can provide context, such as the client's reaction. This makes it richer and more real than the traditional, simplified OR cases. When a good case study has been developed and adapted to fit a module, significant changes are rarely made from year to year.

Students find case studies challenging, especially messy problems that require structuring before getting to the implementation of OR skills. As well as honing students' problem-solving, structuring and IT skills, the cases help them obtain some intuition about OR theory. Working on the case studies in class also prepares students for more substantial, assessed, group cases.



Students' skills are both developed and assessed using case studies and this does not just apply to the transferable skills like group work, analytical thinking and presentation skills. Example C demonstrates that case studies can even be used to include additional programming languages into OR programmes. Bell and von Lanzanauer (2000) use an example to demonstrate how a case study can be used to show the use of OR applied to a real-life problem and that it can provide additional learning, beyond the original learning objectives.

### **Example C: Case studies to teach programming at Cardiff University**

**Provided by: Dr Vince Knight and Professor Paul Harper**

Discussion with employers via an industrial liaison committee revealed that it would be desirable to include Object-Oriented Programming (OOP) skills in the M.Sc. programme. This has been combined with a case study in a module towards the end of the M.Sc. programme when students have already been introduced to some programming. The case study allows students to develop problem-solving skills of tackling a problem whilst learning a new OOP programming language: Python. Students are initially provided with an intensive 2-hour tutorial introducing Python. Online resources are also made available. They are then expected to work in groups with limited time (2 days) to solve a particular OR problem requiring coding. As students are working under intense time-pressure, they also gain further valuable time management and teamworking skills, and can use the 2-day experience for discussion on application forms and in interviews.

This example from an M.Sc. in Operational Research and Applied Statistics demonstrates that, while the appropriateness to the material being taught and how easy it is to use the case study with students are the most important factors, other considerations are also important when selecting case studies.

### **3.3. Advantages and limitations**

This section explores the advantages and limitations of using case studies, in general and specifically in an OR teaching context.

The discussion above has demonstrated many of the advantages of case studies in terms of developing and accessing a range of skills. Along with providing an approximation to real life experience within the taught part of OR programmes, this demonstrates the value of teaching with case studies to improving students' skills for employability. This fits particularly well with the focus on employability in OR teaching discussed above.

Other relevant examples of advantages from the literature are:

- increasing student interest in the topic and motivation for learning (Cochran, 2000; Hassall et al., 1998; Herreid, 2011; Robinson et al., 2003; Stewart & Dougherty, 1993);
- encouraging better retention of the points being taught (Cochran, 2000; Herreid, 2011; Stewart & Dougherty, 1993);
- encouraging implementation of the ideas and methods being taught (Owens, Padula, & Hume, 2002; Robinson et al., 2003).

The literature also identifies limitations of using case studies in teaching such as:

- increased workload for both staff and students (Hassall et al., 1998; Herreid, 1998, 2007; Robinson et al., 2003; Stewart & Dougherty, 1993; Yadav et al., 2007);

- selection of an appropriate case study that meets the objectives of the teaching and has an appropriate level of complexity (Cochran, 2000; Foran, 2001; Herreid, 1998, 2001; Owens et al., 2002; Stanford University, 1994);
- managing students' expectations of what is required of them (Cochran, 2000; Robinson et al., 2003; Stanford University, 1994).

These are reflected in two factors respondents to the online survey find most challenging in using case studies, which are 'developing new case studies' and 'writing briefing documents'. The challenges in developing new case studies are perhaps reflected in the frequency with which case studies are reused, as discussed above.

The majority of respondents develop case studies based on either their own research or research articles from journals; they are also obtained from companies with which respondents liaise, or in a few cases purchased from companies that have developed them for use in teaching. Final dissertation projects, particularly those involving external organisations, are also a good source of case studies. The sources of case studies for use in teaching that we have identified via the surveys include the Harvard Business Review (Harvard Business School, 2014), INFORMS Transactions on Education (INFORMS, 2014) and the Case Centre (Case Centre, 2014).

Example D shows how case studies can be developed based on consulting work.

### **Example D: Case Studies informed by consultancy at the University of Hull**

#### **Provided by: Dr Giles Hindle**

Self-penned case studies based on real-life consultancy are used in the Analytic Consulting M.Sc. module at Hull University. Care is taken to ensure that the cases will only work in a group setting, avoiding the danger of students breaking away from the group and working on the case individually.

Students are given a case pack including a brief, contextual information, and data at the start of the module, after which they are given lectures on consulting and its practice. During the 6 weeks that they are working on the case, they must meet with the "client" to clarify objectives; give a final group presentation; and write a report detailing their recommendations.

A recent example of one such case was based on an intervention to explore differences in estimates of carbon emission levels coming from official and other sources, such as *Car Magazine*. Students were tasked with exploring why the estimates were different. The case pack that was handed out consisted of a prepared brief and some contextual information, along with two data sets, one of which had been developed during the real consultancy project. As part of their work, each group had to act as a group of consultants, interviewing the client and producing a report and presentation making their recommendations.

As part of their experience, students learn about project and client management; teamwork; the importance of communication and meetings; how to extract what is needed from a meeting; and the need to take the initiative.

This demonstrates that there are considerable advantages to including case studies in OR teaching and provides some suggestions to address the significant limitation of the workload involved in developing new case studies.

### 3.4. Demand for training

The online survey also revealed that there is demand for training or collaboration on the development and use of case studies. The most popular suggestion was ‘collaboration to share/develop case studies’ with 21 respondents expressing an interest. This could include making complex data sets, particularly useful for case studies in OR, publicly available. In addition, 14 would be interested in attending training ‘in the writing of case studies in teaching’ and 12 in ‘training on the use of case studies in OR teaching’.

## 4. Conclusions

This article has demonstrated that the inclusion of case studies in OR teaching is widespread, with case studies being used in a range of teaching contexts and assessed in a variety of ways.

Case studies can be used to develop and/or assess a variety of skills both subject-specific and transferable skills. There are a range of advantages to including case studies in the teaching of OR, particularly the development of softer skills and the ability to transfer academic skills to real-life contexts.

This article has identified that a barrier to the use of case studies in OR teaching is the development of new case studies. In addition to identifying suggestions to assist with this, raising the issue should reassure those new to the use of case studies that they are not alone in finding this a challenge.

Overall, it is hoped that this article provides an assessment of the ways in which case studies are used in OR, the advantages and limitations of using them and specific examples of how they can be used effectively which will provide ideas to assist in improving OR teaching.

Swanson and Morrison (2010, p. 94) note ‘our suggestion is not meant to imply that the case study method should be used to the exclusion of other approaches, but it should constitute one of several tools in the training kit’.

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