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A Rational Method of Project Selection by Post-Graduate Students*

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A critical part, and sometimes the whole, of any postgraduate programme is the undertaking by the students of a project. One of the most crucial phases in this undertaking is the project selection. It is also this phase where students, invariably, receive no formal training and this could delay the whole undertaking substantially; in some cases leading to premature abandonment of the project or the degree programme altogether. This paper attempts to fill this gap by providing a framework and a methodology that would enable the student to develop a greater comprehension of the problem and to make a rational choice. The framework is based on decision analysis and comprises a two-stage procedure: (a) technical uncertainty and dominance screening and (b) the application of SMART (Simple Multi-Attribute Rating Technique). A hypothetical case is considered to illustrate the methodology and the results are discussed.

INTRODUCTION

Decision making is what you do when you do not know what to do, Howard [7].

FOR A NUMBER of years the authors have served as departmental tutors for MSc projects. The task involves assisting MSc students in their selection of a project and monitoring their progress during the instruction phase at the end of which individual supervisors take over. More specifically this includes: a seminar on the nature, scope, objectives, resources, management, monitoring, control procedures and assessment of an MSc project; the provision of possible topics for selection; discussions with individual students; liaising with industrial contacts; and group presentations and discussions. In the course of this duty we have repeatedly witnessed the students experiencing difficulties during the selection process, struggling in the face of uncertainty, making decisions against their better judgement (risking), screening, choosing, rejecting, retracting, changing objectives, changing directions and sometimes abandoning projects.

It will, of course, be much easier and straightforward if lecturers do all the choosing and the students are simply required to carry out the projects. However, selection and formulation of the project is a crucial element of postgraduate training and, as such, needs to be undertaken primarily by the students. In this way the student is the decision maker and the project manager and it is the student's responsibility to select and complete a project on time, with the available resources and to the satisfaction of the examiners. A little thought on the subject will convince even the novice that project selection is a very complex process involving multiple attributes which are not easily quantifiable, multiple stages and multiple objectives. To make matters worse, many of these are closely interrelated. It has also been observed that there is much uncertainty in this process and that, in view of this, the students often take risks. Some of these risks cannot easily be appreciated by the inexperienced student in the absence of relevant data. It presents us, therefore, with a challenging problem and certainly a worthwhile topic to apply decision theory in an attempt to imbue some rationality to the project selection process. A literature review on project selection concerning principally R&D projects has produced much convincing evidence on, firstly, the importance of the subject, with hundreds of papers devoted to it [1], and secondly, the similarity of the problems that are addressed by them in spite of perceived differences. The rationality referred to in the title implies the use of rules, associated with a certain approach, in making a decision, hopefully a better decision! This paper will examine the various issues relevant in a decision environment before illustrating the application of decision theory in postgraduate student project selection through a case study by utilising decision models from the classical school.

BRIEF BACKGROUND

In order to facilitate understanding of the problem at hand, some basic characteristics of the decision process and decision makers are briefly mentioned in this section. Figure 1 [2] shows a simple representation of the decision process, indicating why different people make

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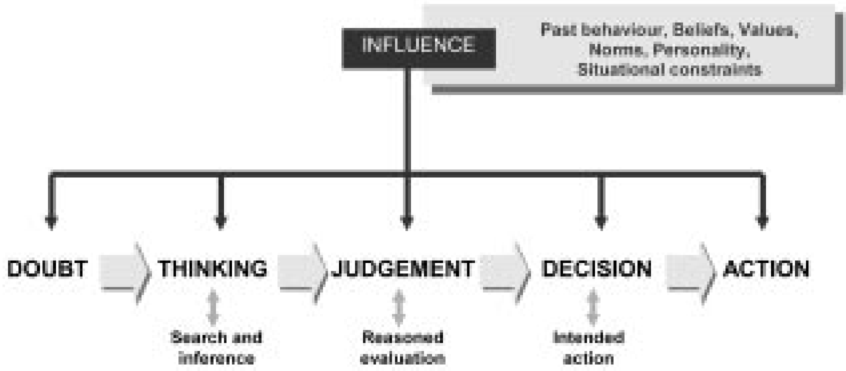

Fig. 1. The decision process [2].

different judgements within the decision environment. The influence of personality, in particular, affects judgement in a way that the taking of a decision cannot be fully explained as the logical result of judgement. A number of personality variables have been used to profile decision tendencies of individuals, with an effective decision maker sharing at least some of the following attributes, [2]:

- internal locus of control (taking fate in own hands)
- high endurance
- flexibility
- responsible attitude
- willingness to take risks
- orderliness
- good understanding of the problem
- innovativeness
- achievement orientation
- self-acceptance
- intellectual complexity
- intellectual efficiency.

Many of the positive characteristics may be inhibited, however, by the natural limitations of the decision process which include the following:

- tendency of staying with the status quo;
- bounded rationality (inability to cope with all available information);
- 'slack' (natural laziness of humans);
- ambiguity (e.g. conflict between social aims and personal preferences);
- rule following;
- fragmented attention;
- stress.

It goes without saying that other forces are also at play, related to the organisational culture which in a way moulds the type of decisions that can be made.

PROBLEM DEFINITION

Description of project 'development'

The word 'project' may lack a precise definition, but it can be readily defined in terms of a complete sequence of tasks that has a definite start and finish, identifiable goals and entity and an integrated system of complex and interdependent relationships [3]. Figure 2 highlights the basic steps involved in project 'development' in which the student plays the role of the project manager but also that of the owner (. . . and the company . . . and the sub-contractor). In compensation, the student receives 'free' consultation by the supervisor (. . . who occasionally is also forced into the role of a sub-contractor). As time passes the commitment grows and, once the point of 'no return' has been reached, a project could either be successfully completed or

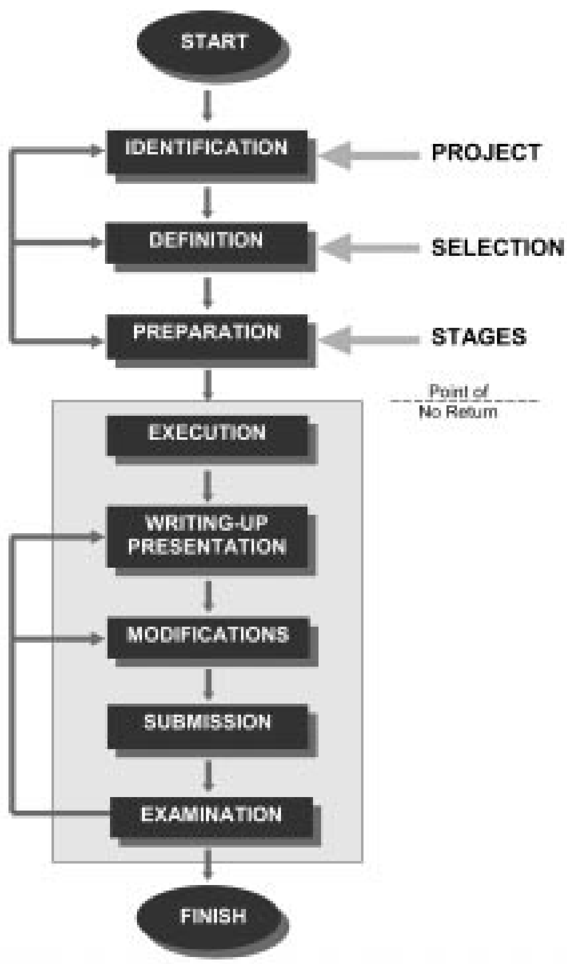

Fig. 2. Project 'development'.

abandoned. At the three stages preceding execution, a student could, in principle, change decision in part or entirety. In practice, the second stage is normally treated as the point of 'no return'. This study will, therefore, address the first two stages.

Description of the problem

Students can have their own ideas or germs of such and indeed many good projects grow out of them. Nevertheless the students will want to compare various ideas, including their own, for their attractiveness. Following a seminar at the beginning of the academic year where the various aspects of Fig. 2 are explained in detail, the students are given a 'Project Book'. This may be either in hard copy or, increasingly these days, a database, but essentially containing a list of projects together with some information on the expected scope, the proposer, initial references and contacts. Students are encouraged to undertake a market research on potential ideas, including discussions with external contacts, consultation with academic staff and colleagues, analysis of own strengths and weaknesses and literature review. The next step in the project identification stage involves an initial evaluation or preliminary screening aimed at reducing the number of possible projects down to a manageable figure, say a maximum of five. The students are subsequently encouraged to undergo a second round of consultation with selected staff/industrial contacts, study additional relevant information, analyse critically project scope and objectives, the resources required and generally think in attempting to select their project. It is this, the definition stage of project selection, that can benefit greatly from a structured approach, methodology and help from decision analysis. Decision analysis will provide the means for a fuller evaluation of the project that would enable a student to choose one project or to reconsider a decision already arrived at from the initial evaluation. In making his decision, the student is faced with many uncertainties and with solutions characterised by different, indeed invariably conflicting, and interrelated attributes. These are described next.

The decision environment

Decision-making can be approached in a more logical way, once its nature is understood. The environment in which the decision-making of project selection is undertaken can be summarised under five headings as follows:

1. *University environment:* MSc courses are in general of intensive nature with much material to be covered within a limited period and a large part of it on a self-learning basis. Coupled with this are the demands of continuous assessment which create a continuous stream of deadlines for the students to meet. The project selection has to take place within this environment. This task, of course, needs to adhere to its own project-specific and tight deadlines.
2. *Project objectives:* As mentioned in the introduction, the project has to finish on time within its cost budget and to a standard that satisfies the examiners (and occasionally the student). Therefore, the problem involves multiple objectives.
3. *Attributes:*
   - Competence (student)
   - Experience (student)
   - Career prospects
   - Subject area
   - Personal interests
   - Supervision
   - Industrial relevance/links
   - Available support (facilities, financial, technical, software)
   - Expected effort required
   - Contribution (e.g. to science)
   - Others (self-satisfaction etc.).
4. *Uncertainties:*
   - Uncertainty on the nature of the problem
   - Technical uncertainty
   - Information uncertainty (knowledge source)
   - Supervision uncertainty
   - Uncertainty on available (timely) support
   - Uncertainty on resource requirements (e.g., time required to perform a task)
5. *Decisions:*
   - Breadth vs depth
   - Scope/objectives
   - Approach (theoretical, experimental, combinations)
   - 'Tool' selection (use available, make own)
   - Degree of novelty/research/innovation.

In view of the complexity and the multitude of problems as can be seen from this, leaving the students to 'carry on with the project selection' appears to be far too optimistic to say the least. Training them to approach such complex tasks in a more logical way should also constitute a valuable part of postgraduate training in any case.

DECISION MODELS

General

Figure 3 [4], offers a guideline on the type of decision model to be used for project appraisal depending on the degree of risk, number of objectives, degree of quantification of relevant factors and degree of interdependence. With the MSc project selection problem, where the degree of quantification is low, the attributes many and not mutually independent, the use of utility in making a decision (devising a multi-attribute utility function) will be extremely complex [5], and is, therefore, considered impractical. This is shown in Fig. 3 where scoring appears to be the popular method. The framework adopted in this study comprises a two-stage procedure: an initial project evaluation through screening and the use of SMART (Simple Multi-Attribute Rating Technique). To illustrate

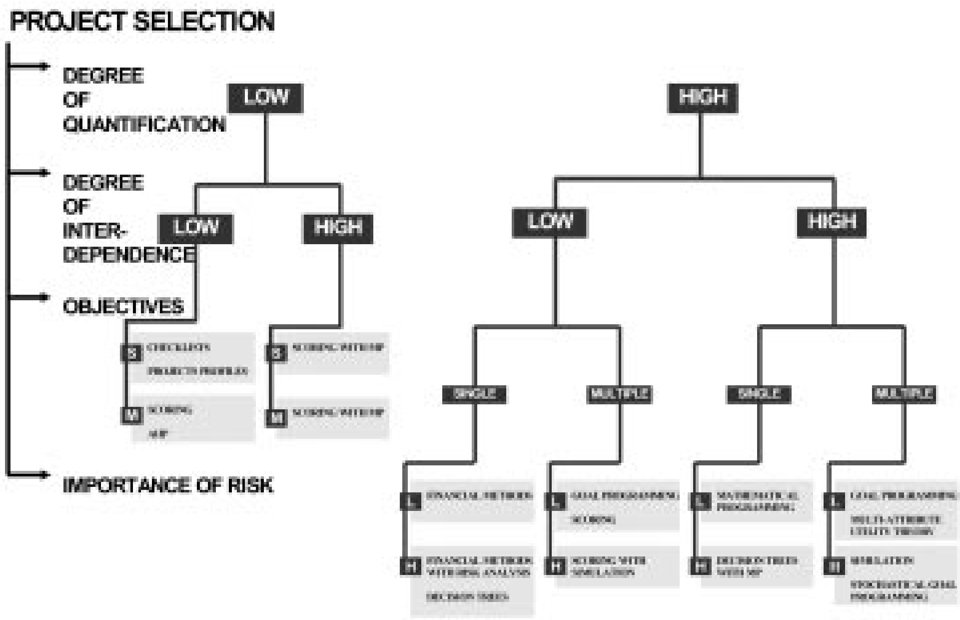

Fig. 3. A framework of project selection models (adapted from [4])
(L → low; H → high; S → single; M → multiple).

the use of these models, a semi-hypothetical case will be considered as described next.

The MSc project selection case

The student in question is a (male) mechanical engineering graduate who decided to change direction and be trained in marine technology through attending a one year MSc course, so that he could find more lucrative employment in the offshore oil industry. Because of his background he would ideally like to tackle a project in subsea engineering of industrial relevance and preferably one that does not go too deeply into naval architecture. This is a sample of a plausible list of projects from which the student has to make his choice in MSc Marine Technology (L1–L4 = academic staff; I = industrial contacts):

- Removal of Marine Fouling from Fish Cage Netting (L1)
- Transportation of Gas (L1)
- Fire Detection System for use in Offshore Installations (L1)
- Conductor Shielding for Reduced Wave (Loads (L2)
- Concrete Floating Production and Storage Systems (L2)
- Subsea Mineral Extraction (L2)
- Chaotic Motions in Cable-Body Dynamics (L3)
- Active Heave Compensation for Effective Subsea Intervention (L3)
- An Integrated Subsea Intervention System (L3)
- Systems Reliability Analysis of Subsea Installations (L4)
- Thrust Augmentation by Slipstream Diffusion (L4)
- Inspection, Repair & Maintenance Systems for Subsea Installations (L4)
- Information Transfer ROV-Human Brain (I)
- Pipe (Line (Laying (I)
- Design of Deep Sea Risers (I)

Initial evaluation

A straightforward way this can be done is by means of a *dominance strategy*, [6], where subjective scoring of High, Medium and Low preferences are designated to each project using only the key attributes. Prior to this, it may be worthwhile to screen the projects on the basis of technical uncertainty, as in most cases students will not consider a project if they believed or discovered that the project is beyond their technical capability. These two screening strategies are illustrated next:

1. *Technical uncertainty screening.* All that this entails is discarding projects which are perceived to be unacceptably risky from a technical point of view. In the case in question, following preliminary discussions and on the basis of the information provided, the student felt that projects 7, 10, 11 and 13 are beyond him and decided to reject them.
2. *Dominance screening.* To illustrate this strategy, it will be assumed that the student considers at this stage that, in addition to competence, the following are key attributes:
   - career prospects
   - subject area
   - supervision
   - available support.

Using these, something of a payoff matrix could be formed as shown, [6]. (Assume H = 3, M = 2, L = 1).

Attributes \ Projects	1	2	3	4	5	6	8	9	12	14	15
Career	L	M	M	M	L	L	M	M	M	M	H
Area	L	M	L	L	L	M	L	M	H	M	M
Supervision	L	L	L	M	M	M	H	H	L	M	M
Support	M	L	L	L	L	L	H	H	H	M	M
SCORES	5	6	5	6	5	6	9	10	9	8	9

Here, one is looking for dominant columns or maximum scores. Considering that the number of projects has to be limited to five, the student selected 8, 9, 12, 14 and 15.

Project selection using SMART

SMART is a well proven methodology and has been found to be extremely robust in practice. The methodology involves a number of stages as follows, [5]:

- Identify the decision maker
- Identify the alternative courses of action
- Identify the attributes which are relevant to the decision problem
- Assign values for each attribute for increasing performance
- Determine a weight for each attribute
- Obtain weighted averages for each alternative
- Make provisional decision
- Perform sensitivity analysis

These stages are considered, in turn:

Value tree: Stages 1 to 3 in the analysis have already been completed. Using the attributes considered in Section 3, a value tree can be constructed as shown in Fig. 4, by combining some of the 'benefits' and by considering as 'costs' the time, effort and the actual project expenditure as well as any opportunity cost that might arise as a result of a delay in completing the project. To achieve decomposability and aiming for minimum size, 'career prospects', 'subject area' and 'industrial relevance' have been combined under 'potential', and 'self-satisfaction', 'contribution' and 'personal interests' under 'personal'.

Value scales: It will be readily seen that the attributes cannot be represented by easily quantifiable variables so that direct rating has to be used to measure the performance of the projects on each attribute. Considering 'potential' as an example, the student's rankings are:

1. Deep sea risers (15)
2. Inspection, repair and maintenance (12)
3. Subsea intervention (9)
4. Pipe laying (14)
5. Heave compensation (8)

On the basis of the above the values allocated by the student to the various projects are shown in the value scale of Fig. 5. Following the same procedure, value scales have been constructed for the remaining attributes and are shown in Table 1.

Weights: Weights for the attributes will be determined by using swing weights, [5]. The student's rankings of the 'benefits' attributes are:

1. Competence
2. Potential
3. Supervision
4. Support
5. Experience
6. Personal

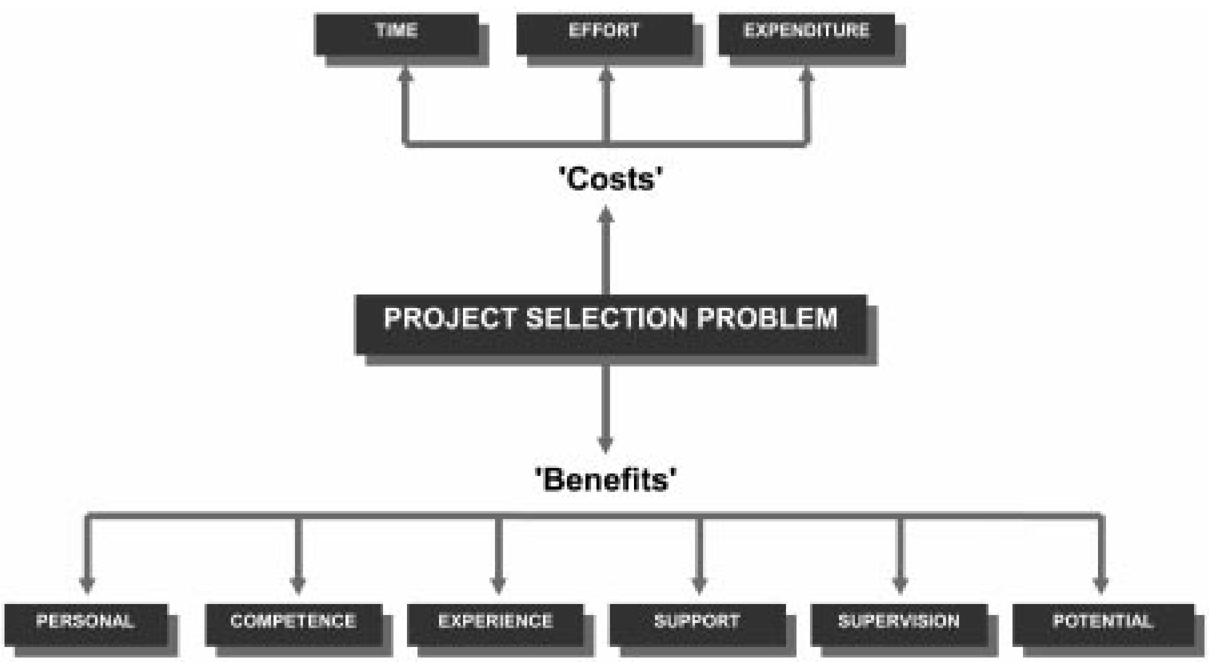

Fig. 4. Value tree for the project selection problem.

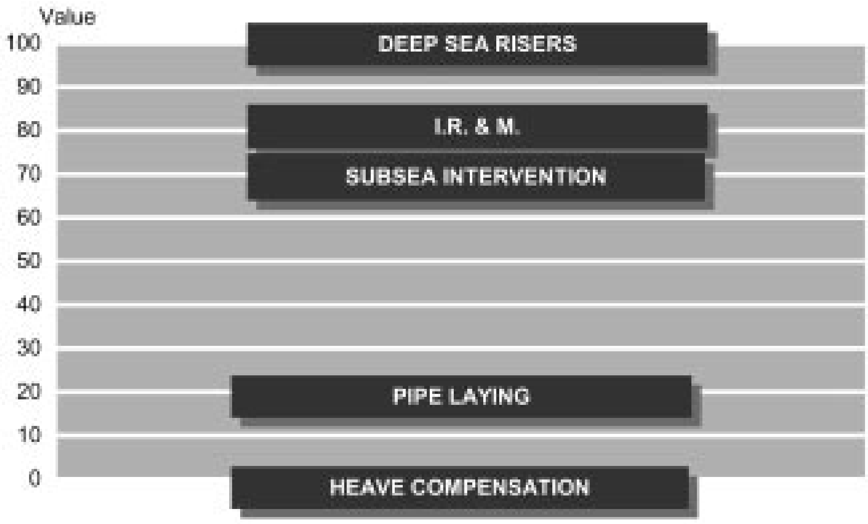

Fig. 5. A value scale for project 'potential'.

Table 1. Values and weights for the project selection problem

Attribute	Weight	Projects (8)	(9)	(12)	(14)	(15)
Competence	30.3	20	0	100	60	50
Potential	24.2	0	70	80	20	100
Supervision	18.2	100	90	0	60	50
Support	15.2	100	80	70	0	30
Experience	9.1	0	20	100	60	80
Personal	3.0	50	60	100	0	40
Aggregate benefits		40.96	49.1	72.4	39.4	61.49
Expected time to complete each project		10½ months	12 months	15 months	14 months	13 months

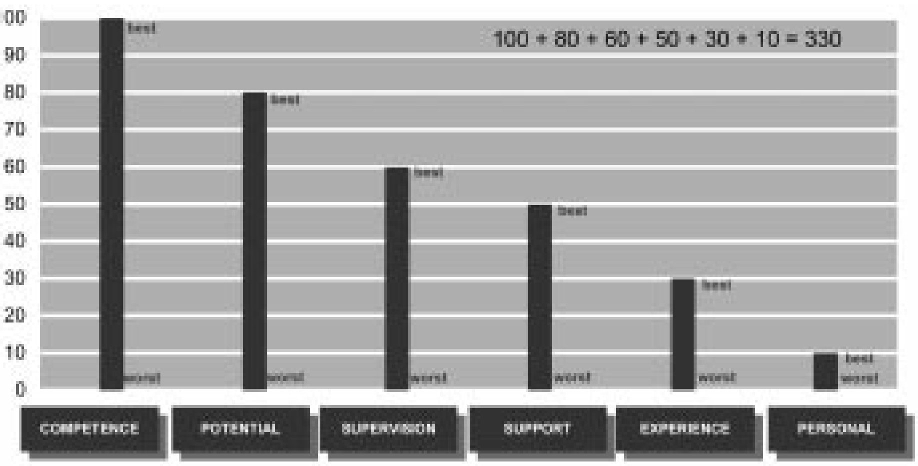

Fig. 6. Derivation of swing weights.

On the basis of the above, the derivation of swing weights is shown in Fig. 6, and the normalised weights are given in Table 1.

Aggregate benefits: Using the additive model, the weighted sums for each project, corresponding to aggregate benefits are shown in Table 1. From the table it can be seen that project (12) has the highest value. The next step derives further information from this analysis by bringing the 'costs' into play.

In this example, the 'costs', like the benefits, are not easily quantifiable. For the purpose of illustration, the dominant cost, which in the case considered must be the time taken to completion, could be used as a basis in order to trade 'benefits' against 'costs'.

Costs/benefits trade-off: The time taken for the completion of the project is a function of many variables linked to the uncertainties associated

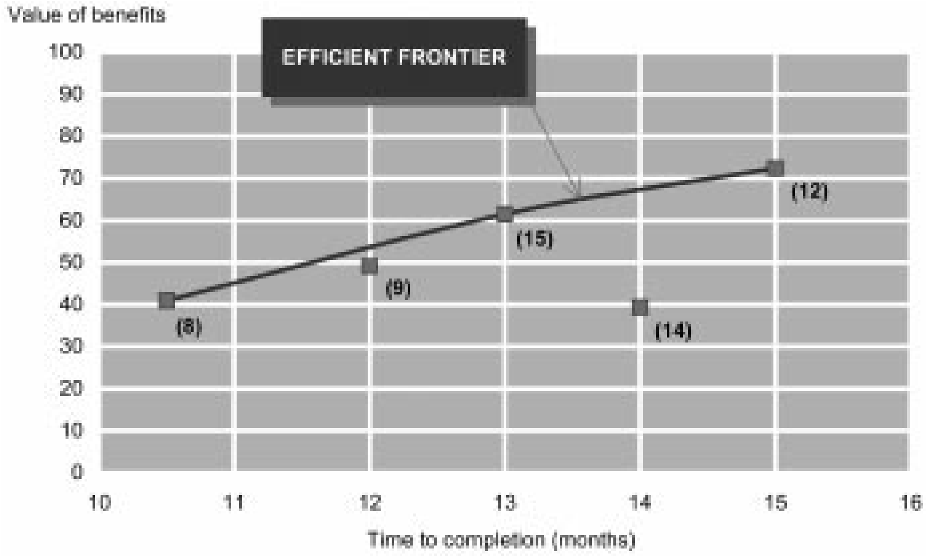

Fig. 7. Costs/benefits trade-off.

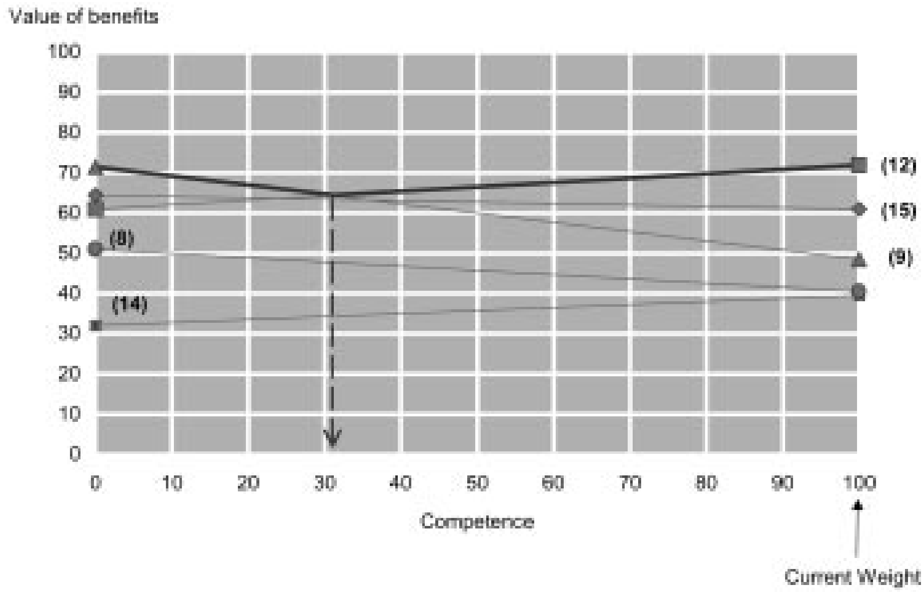

Fig. 8. Sensitivity analysis.

with the undertaking of a project as outlined. Based on all available information and according to the judgement of the student, the expected time to complete each project is shown. Plotting the aggregate benefits against these values, the graph shown in Fig. 7 is produced. From this it will be seen that projects (8), (12) and (15) are on, what is called, the *Efficient Frontier*.

Sensitivity analysis: A close observation of Table 1 reveals that the robustness of the choice for project (12) could only be influenced by changing the weighting of the dominant attribute, namely competence. The result of such a sensitivity analysis is shown in Fig. 8. From this it would appear that project (9) will become a more attractive option than (12) only if the current weight on competence of 100 reduces to just over 30. This is highly unlikely. On the basis of the preceding methodology and analysis, the rational choice by taking into account the student's preferences is project (12).

CONCLUDING REMARKS

On the basis of the study presented in this paper, the following concluding remarks can be made:

- The whole exercise offered a feeling of introspection in that it allowed for an insight to be gained in project selection in a short period of time which surpassed in some respects experiential knowledge of many years.
- A logical framework has been put forward which should allow any individual postgraduate student to reason for his or her choice of a

project and to develop greater understanding of the selection problem through numerical experimentation.

- As one structures and restructures, analyses and re-analyses the problem, it becomes progressively clearer that ultimately, the choice will be one of personal preference.

The student in question chose intuitively project (15)!

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