

# Exploring and Implementing Theories of the Experiential Learning Cycle in the Teaching of Transport Planning

**Erel Avineri, Senior Lecturer in Integrated Transport**

Faculty of the Built Environment, University of the West of England

Email: Erel.Avineri@uwe.ac.uk

## Abstract

Is it possible to teach students who have no previous knowledge or analytical background the basic skills of transport appraisal? This case study, inspired by theories of the experiential learning cycle, proves that it may be possible and even very successful. The case study focuses on some learning and teaching methodologies introduced to the module 'Transport Economics and Appraisal' in the Transport Planning MSc Programme at the University of the West of England, Bristol. The described approach may be relevant to a wide range of courses in the built environment, where analytical skills are required by employers but not necessarily developed and practised in class.

**Keywords:** Experiential Learning Cycle, Learning Styles, VARK (Visual, Aural, Read/write and Kinesthetic), Transport Planning

## Good Practice Points:

- Individual differences in students' learning styles are very wide. These differences may be treated by introducing multimodal teaching components, by providing students with self-learning material and by designing teaching activities that are assigned to different stages/modes of the experiential learning cycle.
- Using several teaching modes addresses students' different learning styles. It also helps in maintaining students' attention and interest levels. Experiential learning through the case study was considered by the students to be fun and a welcome change from traditional lecture-based teaching.
- Teaching and learning activities can be planned and designed in a flexible way in order to offer each learner more possibilities to spend additional time on his or her preferred learning style.
- The above issues resulted in deeper learning than the conventional approach, as reflected by students' feedback and by the module assessments.
- Although they seem to be simpler and less intensive than traditional didactic lectures, interactive sessions require *more* preparation work, since detailed planning is needed in order to make them effective.
- By providing self-learning material, it is possible to continue the experiential learning cycle even after the session is over, to encourage reflection and to increase the impact of a single session.
- Readers may find Moon (1999) a valuable source of information that provides some more examples of how teaching activities can be improved by applying experiential theories, and particularly by encouraging reflection.

## Background

One of the major roles of a transport planner is to provide systematic and objective information to support decision-making. Many think transport planning works mainly at the interface between quantitative analysis of transport schemes and the level of policy making; with the information and analysis needed by policy makers to choose among alternative strategies for improving the performance of our transport systems and to reduce the negative impacts of it. This led many transport professionals to an emphasis on quantitative technical studies (see review in Wachs, 1985). The practice of transport planning has evolved much over the past decade. A new approach to the appraisal of transport projects and schemes has been introduced by the Government in its White Paper “A New Deal for Transport” (DETR, 1998). The range of aspects and factors to be considered in the transport appraisal process has become much wider. Economy, Environment, Safety, Accessibility and Integration are assessed. Most government agencies require economic evaluation of transport (as well as non-transport) projects as part of the appraisal process. The guidance to carrying out appraisal in Government is found in “The Green Book” (HM Treasury, 2003), the latest version of which was released in January 2003. It states that proposals need to be underpinned by sound economic analysis, which should be provided by a cost benefit analysis in an option appraisal. This economic rationale may help develop a value for money solution that meets the objectives of government action.

Transport planners are expected to provide data incorporated in the appraisal process, analyse it, and provide the decision makers with recommendations on the preferred policy. Moreover, transport planners may have a role in bringing about social change and representing some of the interests of the socially excluded; therefore, they are expected to critically evaluate procedures applied in transport planning. In order to achieve these, transport planners now more than ever need an extensive base of knowledge and quantitative skills. However, not all of the students on transport planning programmes have the analytical background to support the required decision-making skills. This may provide some explanation as to why much of the teaching in transport planning programmes in the UK is carried out in an abstract way, i.e. out of context, without examples and in the absence of direct involvement from students. This might cause the dominance of a surface learning approach being taken by students.

The module ‘Transport Economics and Appraisal’ is one of the core modules of the MSc Programme in Transport Planning at the University of the West of England, Bristol. One of the learning outcomes of this module is to critically evaluate appraisal procedures applied in the assessment of transport planning options. This is done by an in-depth examination of traditional means of assessing planning options, such as cost-benefit analysis (CBA), and their use in the appraisal of transport policies and projects. It is important that transport planners will get familiar not only with the techniques but also with the philosophical aspects of transport appraisal (for example, the issue of handling risk and uncertainty in transport appraisal, which is explored in the context of this case study), and recognise the merits and

drawbacks of alternative methodologies. This cannot be done without in-depth understanding of the methodological aspects of CBA.

One may argue that analytical skills, such as those required in CBA, cannot be developed and practised in class. Due to the lack of relevant quantitative background, transport planning students are believed to be unable to cope with complex issues, such as risk analysis. Therefore analytical skills of transport planning are often neglected or described in general terms. The next section describes theories that may be relevant to learning and teaching in transport planning; and the application of these theories is then demonstrated in a case study. This paper is concluded with some key lessons learned from the case study.

### The Experiential Learning Cycle

Experiential Learning seems to mirror the way we naturally learn. One of the most helpful theories of learning is embodied in the idea of the *Experiential Learning Cycle* (Kolb, 1984). It proposes an iterative series of processes which underlies learning. There are four stages:

- *Concrete Experience (CE)*: One can not learn something simply by watching or reading about it; active involvement is necessary.
- *Reflective Observation (RO)*: Student attention should be focused on particular elements of the experience. This means taking time out of doing and pausing to consider what has just taken place.
- *Abstract Conceptualisation (AC)*: through a process of inductive reasoning, the students analyse observations, explain them, and integrate them into logically sound theories.
- *Active Experimentation (AE)*: The students consider how they are going to put what they have learnt into practice.

Learning becomes less efficient where one or more of the learning cycle stages is missing, or where a student lacks the skills or opportunity to deal with one of them (James, 1999). An important cycle stage that should not be neglected is *Concrete Experience*, where active involvement by the students is necessary. Active experimentation is highly important; for learning to be useful, most people need to put it in a context that is relevant to them. If one cannot see how the learning is useful to one's life then it is most likely to be forgotten quickly (Hembree, 1992). Moon (1999) questioned whether the cycle of experiential learning is really about the *teaching* process or *learning*. She reviewed the place of reflection in the body of the literature on experiential learning, and challenged its original definition by Kolb. Perhaps the most important finding that arises from her study is that a means of locating reflection in different stages of the learning process should be provided; this can be effective in 'upgrading' learning that has taken place in the other stages of the cycle. Some theoreticians, such as Schön (1987), suggest that reflection can even take place during action. However, this approach has been much criticised (see Moon, 1999).

### Application to the Teaching of Transport Appraisal – A Case Study

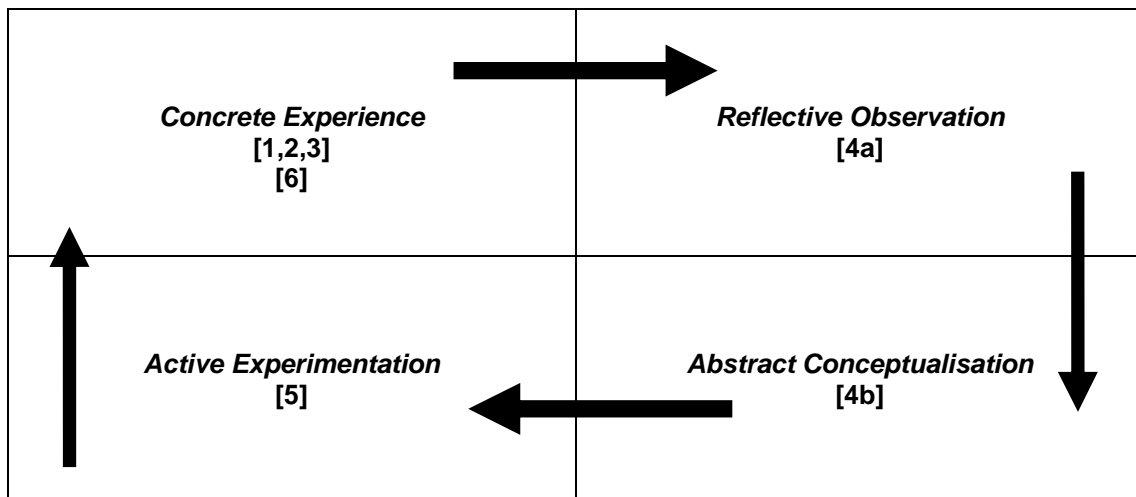
In the author's opinion, applying the Experiential Learning Cycle in class may be very useful in the teaching of CBA and other quantitative issues. This case study observes the teaching methodology used in order to help students develop an awareness of various risk issues in the transport appraisal process, to apply spreadsheet techniques to support the decision making and to critically address some of the common appraisal approaches. The learning and teaching activities have been designed in order to address each of the learning cycle stages in a session of the postgraduate module 'Transport Economics and Appraisal' at the University of the West of England. This was the ninth session of this module. Excel had already been used by the students in previous sessions and in other modules as well, and all of them have developed basic skills with it. The students were familiar with concepts and techniques, such as NPV (Net Present Value).

The central practical applications of the theory of the Experiential Learning Cycle, as applied by the author in his teaching activities, included the following:

- How a session, or a whole module, can be developed in a way that takes students systematically around the whole cycle;
- A consideration of the teaching methods that are particularly valuable at particular stages of the cycle.

In order to help students to progress through each of the stages, there was a need to plan and design teaching activities in advance. At the early stages of planning this session, Kolb's cycle stages were converted into activities which complement and build upon each other while contributing to the learning objectives of this session (and module). These activities are detailed in Table 1 in Appendix 1.

Interactive handouts have been used in this session, as well as a combined Excel/PowerPoint presentation. Students were asked to fill in the missing values in the spreadsheets (see Appendix 2). Calculations of economic indicators were then demonstrated by the lecturer using Excel. This was demonstrated by a spreadsheet that followed the previous one, in which the missing values were completed, and additional questions provided. This activity was followed by the comparison of project alternatives. Another interactive activity was designed in order to introduce sensitivity analysis of the results to case study parameters, and to discuss the importance of such analysis in the appraisal process. In general, teaching and learning activities were planned and designed in a flexible way in order to offer each learner more possibilities to spend additional time on his or her preferred learning style.



**Figure 1: Demonstration of Kolb's Cycle**

An ideal learning environment would include each of the four processes. The following are a few examples of the activity types used in order to address each of the stages of Kolb's cycle presented in Figure 1. The numbers in brackets represent the assigned teaching activities detailed in Table 1.

*Concrete Experience [1, 2, 3]*

- One cannot learn about transport appraisal by simply reading about it. The cycle began with the lecturer describing some of his practical experience. Effectively this was giving the student a 'substitute' concrete experience. Students who had concrete experience with this subject were invited to share it with their colleagues in a semi-structured class discussion.
- Students were introduced to the topic of appraisal and risk analysis with easy tasks of simple problem solving to gain experience.

*Reflective Observation [4a]*

- Based on the above experiences, different factors that affect decision making in risky decisions have been discussed in class. It was important to seek many questions at this stage in order to reflect on students' experience, looking for meaning.

*Abstract Conceptualisation [4b]*

- Continued discussion was focused by the lecturer on the comparison between the previous knowledge of transport appraisal (gained in the previous sessions of this module) and the new concepts demonstrated and discussed in the previous stages. This applied the meaning reflected at the previous stage to form a logical conclusion, described in a quantitative (equations) and qualitative way.

### *Active Experimentation [5]*

- Students were given a quantitative assignment, working in pairs. The students experimented with similar (slightly more complex) problems, which resulted in new concrete experiences.

At this time, the learning cycle started again. With each cycle the students were introduced to new and different experiences. In order to maximise the advantages of experiential learning, interactive handouts and interactive Excel Spreadsheets have been developed by the lecturer, introduced in class and used in an intensive way (see Appendix). The numeric example used in this case study is based on Powell (2001). The complexity and comprehension of the activities were gradually increased with each cycle, until the learning outcomes were achieved.

It is well known that learners are inspired by examples of how (abstract) principles are applied in real life by real people in real situations (Ahmet and Fallows, 1999). The lecturer and the module leader of this module have carefully selected a report by a consulting company, dealing with some of the issues discussed in this module. The students were provided with this report at the beginning of the term, and instructed to write an essay which considered the strengths and weakness in the appraisal procedures applied by the authors of this report. At the end of this session, the lecturer acted as an effective catalyst for learning, leading a discussion about the practical aspects of treating risk in this specific appraisal project. Students were enthused by the real example, tangible to their practical interests.

Following Honey & Mumford (1986), Costello (1991) and Fleming (1995), we were interested to allow all students, no matter their preferred style, the opportunity to become involved in the learning activities. Therefore, teaching materials assigned to each of the stages have been presented in a variety of methods, reflecting different learning styles. A variety of teaching tools, described in Table 1, were assigned to each of the learning cycle stages. This was done in order to best meet individual learning and to maximise the quality of learning, as follows:

- *Activists*: Learning by doing, they need to get their hands dirty.
- *Theorists*: Like to understand the theory behind the actions.
- *Pragmatists*: Need to be able to see how to put the learning into practice in the real world.
- *Reflectors*: Learning by observing and thinking about what happened.

In order to address the needs of each of the groups identified above in the teaching strategy, a variety of teaching aids/techniques have been used in this session, as described in Table 1. Following Honey and Mumford (1986), *activists* are believed to learn best when they are faced with new experiences and problems, and when working with others in team tasks, mainly when the tasks defined are difficult and challenging. Interactive handouts and spreadsheets have been used in this session, introducing the students to some challenging appraisal problems that do not have a definitive and obvious solution. This task, defined as

This case study was commissioned and funded by the Centre for Education in the Built Environment

a team task (pairs/trios), addressed the activists' learning style. It was found to be very effective in increasing involvement, enthusiasm and in-depth thinking. Other tasks students were introduced to were more complex but also more structured (more analytical but less subjective). Such tasks addressed the *theorists'* learning styles. This style of learning was also supported by models, concepts and facts during the sessions. Case studies and consultants' reports were used in order to present examples of the way things are done in "real life" and to make links between the teaching topic and the professional environment; this was done mainly to engage the *pragmatists*. The *reflectors'* style of learning is supported mainly by class discussions and home assignments. About half of the students had been identified in advance by the teaching team to have a specific learning style (for example, many part-time students who are employed as consultants were easily identified as pragmatists). It was less clear what the preferred learning style of other students was; it is likely that they had a mixed learning style. It has been identified by the author that the level of engagement and the contribution made in each of the activities varied much within the students; this has nicely followed the teaching strategy, and provided an opportunity to each student to take part in activities that best fit her individual learning style. There has been no evidence that any of the above groups performed better than others; however, having a variety of learning styles within the group, and different activities to address them was found to be successful in engaging all of the students.

Learning styles may be related to the sensory modes of presentation by which learners' prefer to take in new information. VARK is an acronym that stands for four major sensory modes of learning: visual, aural, reading/writing and kinesthetic (Fleming, 1995; VARK, 2006), depending on the neural system with which a learner prefers to receive information. Thus VARK is a perceptual, instructional preference model that categorizes learning by sensory preferences.

As described in Table 1, the lecturer presented information using all four VARK styles. This was done in order to allow all students, no matter what their preferred style is, the opportunity to become involved. It also allows a student to be presented with the other three methods for reinforcement. It may be argued that every individual has a multimodal learning profile in which all VARK components are represented, but within that profile some have a particular set of preferences. Therefore, a multimodal teaching approach may appeal to all modalities.

Costello (1991) highlighted the importance of individual differences in learners, related to analytical teaching activities. He considered the issue of students having different learning styles and recommends that the teacher avoid a narrow consistent style of teaching and include a variety of styles. In order to deal with students' lack of analytical background, the lecturer attempted to engage as fully as possible with the needs of each student by circulating amongst the students, providing feedback and encouraging debates. Teaching methods and strategies included discussions, rounds, team work, brainstorming and a mini role-play (for a comprehensive list of teaching strategies see James, 1999).

## Encouraging Experiential Learning After the Session is Over

Is it possible to continue the experiential learning cycle even after the session is over? The author believes that the answer to this is positive. In order to offer the student another opportunity to deal with more experiential learning, mainly the concrete experience, students were provided with self-learning material. They were advised to use the same Excel template that was demonstrated in class. Four different experiential tasks were defined: (1) replicate the results of the different scenarios that were discussed in class; (2) run Sensitivity Tests of their own; (3) solve a completely new example about the treatment of risk in transport; (4) analyse a case study and reflect on opinions about the treatment of risk in transport appraisal. Only the fourth assignment was assessed, as part of an essay. This was done in order to provide the students with an opportunity to reflect back on the previous activities and use the method of analysis (Active Experimentation) the next time they encountered an appraisal problem (Concrete Experience). Students might discuss that experience with their colleagues (Reflective Observation), and perhaps suggest that further reading about more theoretical aspects of it (Abstract Conceptualisation), would allow them to observe the risk issues involved and their experience would be transformed by that learning.

Following Moon (1999), the tasks included in the self-learning material have been designed in order to encourage reflection and to increase the impact of a single session. The examples and the consultants' report chosen for the assignment deliberately involved ill-structured data and problems with no 'right' or 'wrong' answer. The students were exposed to 'real-life' situations that challenge assumptions that have been explicitly or implicitly mentioned to stimulate risk analysis; and most importantly – the multi-criteria of the transport problems exposed students to situations in which they were challenged to commit themselves to judgments or choices.

## Lessons Learned

The described teaching session was observed by a tutor from the Faculty of Education at the University, and informally evaluated through conversations with 10 students taking part in this module. Oral and written feedback has been provided by the students at the end of the module. A high level of satisfaction was achieved, and evidence of in-depth thinking by most of the students has been identified in the summative assessment at the end of the project. Specifically, 80% of the students stated that the prior knowledge assumed was 'not too little and not too much', 83% stated that the organisation of the learning and teaching activities was good or very good, 75% stated that their interest in transport economics and appraisal had been increased as a result of the module.

In the general remarks section of the feedback form, several students specifically mentioned the variety of activities as a good feature of the module. One student mentioned that, "I don't like listening to long and boring lectures, and cannot always understand the equations. It was easier for me to understand it during the class exercise on cost benefit analysis" (this student may be an activist/pragmatist by her learning style). Another student mentioned that "this module can be improved by more homework, so that practical

understanding of the economic appraisal would be better assessed” (this could be another activist/pragmatist). One student suggested “this module can be improved by more use of media (TV, newspapers...)” and another student made a similar point: “this module could be improved by more interactive learning... such as a video”. The success of introducing multimodal teaching, and the above comments by the students, encouraged the lecturer to keep on exploring ideas and teaching aids. Next year, media items related to economic appraisal of transport scheme will be introduced in the teaching of this module.

Several key lessons have been learned from this work. First, it has been identified that quantitative aspects of transport planning suffer from having out of context teaching. As a result, the surface approach might become students’ dominant learning pattern. Another issue is that the individual differences in students’ learning styles are very wide. The above issues can be addressed by introducing multimodal teaching components into the classroom. Addressing different stages/modes of the experiential learning cycle by careful design of teaching activities may lead to in-depth learning and to a satisfying way of learning, as has been reflected by students’ enthusiasm during this session, and the positive feedback provided by the students at the end of this module. Finally, another key lesson can be learned from this experience. Although they seem to be simpler and less intensive than traditional didactic lectures, interactive sessions require *more* preparation work, since detailed planning is needed in order to make them effective. However, the author believes that the time spent in preparation is an essential investment that will be repaid many times over.

The above lessons will guide changes in our approach to the teaching of transport planning over the coming year. The author’s main conclusion is that it is possible to change students’ learning approaches, and to get them more involved. A positive impact on the quality of students learning was achieved through changes in the lecturer’s teaching methods and the module design. By careful design of assessment and teaching activities, deeper understanding and competence can be promoted. The success of introducing multimodal teaching, with more visual and kinesthetic components, encouraged the author to persist in exploring new ideas and teaching methodologies.

## Acknowledgments

The author would like to thank the anonymous referees and his colleagues, Dr. Graham Parkhurst and Dr. Kiron Chatterjee, for their comments which helped refine the content of this paper.

## References

- Ahmet, K. & Fallows, S. (1999) Editor's Concluding Remarks. In Ahmet, K. & Fallows, S. (Eds.) *Inspiring Students – Case Studies in Motivating the Learner*. London: Kogan.
- Costello, J. (1991) *Teaching and Learning Mathematics 11-16*. London: Routledge.
- DETR (Department of the Environment, Transport and the Regions) (1998) *A New Approach to Appraisal: Guidance on a New Deal for Transport*. London: HMSO. Available online: <http://www.webtag.org.uk/archive/nata/guidance/index.htm>
- Fleming, N.D. (1995) I'm Different; Not Dumb. Modes of Presentation (VARK) in the Tertiary Classroom. In Zelmer, A. (Ed.) *Research and Development in Higher Education, Proceedings of the 1995 Annual Conference of the Higher Education and Research Development Society of Australasia*, 18, 308–313.
- Hembree, R. (1992) Experiments and Rational Studies in Problem Solving: A Meta-Analysis. *Journal for Research in Mathematics Education*, 23, 242-273.
- HM Treasury (2003) *The Green Book, Appraisal and Evaluation in Central Government*. London: HM Treasury. Available online: <http://greenbook.treasury.gov.uk/>
- Honey, P. & Mumford, A. (1986) *The Manual of Learning Style*. Maidenhead (Berks.): Ardingly House.
- James, D. (1999) The Creative Professional; Learning to Teach 14-19 year olds. In Ashcroft, K. and James, D. (Eds.) *The Creative Professional- Learning to teach 14-19 year-olds*. London: Falmer Press.
- Kolb, D.A. (1984) *Experiential Learning: Experience as the source of learning and development*. New Jersey: Prentice Hall.
- Moon, J.A. (1999) *Reflection in Learning & Professional Development, Theory and Practice*. London: Kogan Page.
- Powell, T. (2001) *The Principles of Transport Economics*. London: PTRC Education and Research Services Ltd. (pp. 132-139).
- Schön, D. (1987) *Educating the Reflective Practitioner*. San Francisco: Jossey-Bass.
- VARK (2006) *A Guide to Learning Styles*. Available online: <http://www.vark-learn.com/english/index.asp>
- Wachs, M. (1985) Planning, Organizations and Decision-Making: A Research Agenda. *Transportation Research*, 19A, 521-531.

## The Author

Dr Erel Avineri is a Senior Lecturer in Integrated Transport at the Faculty of the Built Environment, University of the West of England, Bristol. He received his degrees in Industrial Engineering and Management (B.Sc.) and Transportation Sciences (M.Sc.,

This case study was commissioned and funded by the Centre for Education in the Built Environment

Ph.D.) from the Technion - Israel Institute of Technology. Erel Avineri has been a project manager and a consultant to more than 50 companies and government agencies in the areas of transport planning and operations management. His teaching activities have included lecturing on several engineering and business management programs. His current teaching responsibilities include leading the modules 'changing travel behaviour', 'transport economics and appraisal' and 'transport systems and logistics' and lecturing in various transport planning modules.

## Appendix 1

**TABLE 1 – Teaching Plan of the Session**

Teaching Activities (In chronological order)	Teaching Aids	Tutor/ Student Centred	Stage - Experiential Learning Cycle (Kolb 1984) <sup>1</sup>	Style of Learning (Honey & Mumford, 1986)	VARK Learning Styles (Fleming, 1995)
<b>[1]</b> Listening to explanations on what risk is and how it is treated in the transport appraisal process	PowerPoint presentation	Tutor input only	CE	<i>Theorists</i>	Visual Aural Read/Write Kinesthetic (some animation aspects)
<b>[2]</b> Sharing the lecturer's (and several students') practical experience	Discussion	Tutor led with student interaction; summary of discussion by the lecturer only	CE	<i>Theorists</i>	Aural
<b>[3]</b> simple problem solving	PowerPoint presentation	Tutor led with student interaction	CE	<i>Activists</i>	A mix of all styles
<b>[4]</b> Different factors that affect the decision making	Discussion	Tutor led with student interaction; summary of discussion by the lecturer only	RO+AC	<i>Reflectors</i>	Mainly Aural
<b>[5]</b> Practising: class activities, working in pairs	Interactive handouts and spreadsheet (see Appendix)	Only students, with the tutor acting as personal adviser to each of the teams	AE	<i>Activists</i>	Mainly Read/Write
<b>[6]</b> Discussing aspects of Risk in Transport Appraisal	Discussion	Student-centred: tutor led with student interaction; summary of discussion by the lecturer only	CE	<i>Theorists</i>	Aural

<b>[7]</b> Going step-by-step through a set of equations	PowerPoint presentation	Tutor centred with minor student interaction	AC+AE (some)	<i>Pragmatists</i>	Visual Aural Read/Write
<b>[8]</b> Going step-by-step through an interactive Excel spreadsheet	Interactive Excel spreadsheet	Tutor led with student interaction	AE	<i>Pragmatists/Activists</i>	Visual Aural Read/Write Kinesthetic
<b>[9]</b> Repeating activities #2 to #5 several times, in order to gradually introduce more and more complex issues and in order to encourage deeper learning (mainly AE)					
<b>[10]</b> Discussion of practical issues	Report (provided in advance)	Student-centred: tutor led with student interaction; summary of discussion by the lecturer only	AE+RO	<i>Pragmatists</i>	Aural
<b>[11]</b> Providing self-learning material (keep on practising at home)	self-learning material (available on-line)	In class: tutor Input only At home: only students	AE	<i>Pragmatists/Activists</i>	Visual Read/Write Kinesthetic
<b>[12]</b> Providing students with more reading material	References	Only students	CE	<i>Theorists</i>	Read/Write
<b>[13]</b> Assessment: Recording your thoughts about treating risk in an essay Analysing a Specific Case Study	Essay Questions	Only students	AE	<i>Reflectors</i> <i>Pragmatists/Activists</i>	Read/Write

<sup>1</sup> CE = Concrete Experience; RO = Reflective Observation; AC = Abstract Conceptualisation; AE = Active Experimentation

## Appendix 2

### Interactive Handouts / Spreadsheet used in Teaching

The following handouts were used in the teaching session described in the case study. All students were equipped with calculators, and worked in team of two-three individuals. Each page was handed out separately, introducing problems with different levels of complexity to reflect some of the challenges transport planners are faced with.

The teams' recommendations have been discussed in class, and were supported by analysis and graphs produced in real-time using the electronic spreadsheet. In-depth understanding of economic appraisal process, and critical awareness to methodological concepts, were discussed in a semi-structured discussion, using the electronic spreadsheet as a powerful tool to run sensitivity analysis and analyzing 'what-if' scenarios.

As an example of using the spreadsheet, an output screen of one of the base-line scenarios is given at the end of this appendix.

## The Treatment of Risk in Economic Appraisal

### Alternative Sites for a New Toll Bridge<sup>1</sup>

A project for a new privately financed road bridge connecting two towns over a river estuary is being considered. A private company has already paid £2 million to the Government for the right to design, build and then operate a bridge for 20 years, after which the bridge has to be handed over to the Government.

There are two alternative sites for the bridge. The cost of constructing and operating each bridge is described in the box. Which, if any, bridge should the company construct?

- **Bridge A would cost £22 million (including interest on capital during construction) and save 10 miles. Bridge B further downstream and rather longer would cost £40 million but would save 20 miles.**
- **The company is permitted to charge a toll of £1 for the small bridge A and £2 for the longer bridge B.**
- **They estimate that it will cost them £0.8 million a year to operate and maintain the small bridge including staffing the toll booths and £1.2 million to operate and maintain the larger bridge.**

---

<sup>1</sup> This case study is based on Powell 2001, p 133

The answer will depend upon the traffic using the bridge. The company's consultants have estimated a range of probable base year traffic. This is shown in the following table.

Base Year Traffic	Bridge A		Bridge B	
	Traffic Range	Probability	Traffic Range	Probability
Very Low	6,000-7,000	0.1	4,800-5,600	0.1
Low	7,000-8,000	0.2	5,600-6,400	0.2
Medium	8,000-9,000	0.4	6,400-7,200	0.4
High	9,000-10,000	0.2	7,200-8,000	0.2
Very High	10,000-11,000	0.1	8,000-8,800	0.1
		1.0		1.0

Source: Consultants' assumptions

The Consultants have also estimated that over the 20 years there is a 30% chance that there will be a low traffic growth of 1% per annum, a 50% chance of medium traffic growth of 2% per annum, and a 20% chance of high traffic growth of 3% per annum. The Consultants have confirmed that there is a sufficient capacity on both bridges to cater for the forecast traffic.

If the five base year traffic forecasts are combined with the three traffic growth rates, there is a total of \_\_\_\_\_ sets of traffic forecasts over the 20 year period for each bridge.

For example, the probability of a *Very Low* base year traffic and a *High* traffic growth is \_\_\_\_\_

The probability of a *Medium* base year traffic and a *High* traffic growth is \_\_\_\_\_

E. Avineri: Exploring and Implementing Theories of the Experiential Learning Cycle in the Teaching of Transport Planning

A simple Excel spreadsheet was constructed to calculate the potential financial NPV of each of these sets of forecasts, assuming an opportunity cost of capital of 8% in real terms. The results are shown in the following table.

Base Year Traffic	Traffic Growth	Probability	Bridge A		Bridge B	
			NPV (£ mil)	Expected Value of NPV (£ mil)	NPV (£ mil)	Expected Value of NPV (£ mil)
Very Low	Low	0.03	(3.461)	-0.104	(9.490)	-0.285
	Medium	0.05	(1.393)	-0.070	(6.180)	-0.309
	High	<b>0.02</b>	0.905		(2.503)	-0.050
Low	Low	0.06	0.696	0.042	(2.838)	-0.170
	Medium	0.10	3.083		0.981	
	High	0.04	5.734	0.229	5.223	0.209
Medium	Low	0.12	4.853	0.582	3.813	0.458
	Medium	0.20	7.558	1.512	8.142	
	High	<b>0.08</b>	10.563	0.845	12.950	1.036
High	Low	0.06	9.010	0.541	10.465	0.628
	Medium	0.10	12.034		15.302	
	High	0.04	15.392	0.616	20.676	0.827
Very High	Low	0.03	13.168	0.395	17.116	0.513
	Medium	0.05	16.509	0.825	22.463	
	High	0.02	20.221	0.404	28.402	0.568
<b>Total</b>		1.00		_____		_____

Source: Own calculations based on assumptions given.

*Which, if any, bridge should the company construct?*

E. Avineri: Exploring and Implementing Theories of the Experiential Learning Cycle in the Teaching of Transport Planning

A simple Excel spreadsheet was constructed to calculate the potential financial NPV of each of these sets of forecasts, assuming an opportunity cost of capital of 8% in real terms. The results are shown in the following table.

Base Year Traffic	Traffic Growth	Probability	Bridge A		Bridge B	
			NPV (£ mil)	Expected Value of NPV (£ mil)	NPV (£ mil)	Expected Value of NPV (£ mil)
Very Low	Low	0.03	(3.461)	-0.104	(9.490)	-0.285
	Medium	0.05	(1.393)	-0.070	(6.180)	-0.309
	High	<b>0.02</b>	0.905	0.018	(2.503)	-0.050
Low	Low	0.06	0.696	0.042	(2.838)	-0.170
	Medium	0.10	3.083	0.308	0.981	0.098
	High	0.04	5.734	0.229	5.223	0.209
Medium	Low	0.12	4.853	0.582	3.813	0.458
	Medium	0.20	7.558	1.512	8.142	1.628
	High	<b>0.08</b>	10.563	0.845	12.950	1.036
High	Low	0.06	9.010	0.541	10.465	0.628
	Medium	0.10	12.034	1.203	15.302	1.530
	High	0.04	15.392	0.616	20.676	0.827
Very High	Low	0.03	13.168	0.395	17.116	0.513
	Medium	0.05	16.509	0.825	22.463	1.123
	High	0.02	20.221	0.404	28.402	0.568
<b>Total</b>		<b>1.00</b>		<b><u>7.348</u></b>		<b><u>7.805</u></b>
Total NPV's less than £2.5 million reduced by the shortfall below £2.5 million				<b><u>6.834</u></b>		<b><u>6.439</u></b>

Source: Own calculations based on assumptions given

***Which if any bridge should the company construct?***

*A / B / do nothing*

*1. NPV: Which alternative has the higher NPV?*

*A / B / do nothing*

*2. Risk: Which of the alternative is more risky?*

*A / B / do nothing*

**NPV Calculation: Self-Learning Material**  
**INSTRUCTIONS:** Use this EXCEL template in order to replicate the example that has been demonstrated in class. (The results of 15 different scenarios have been provided)  
 You may use this spreadsheet in order to run SENSITIVITY TESTS as well

## Assumptions

cost of capital	8%
base year traffic	6,500
traffic growth	1.0% per annum
toll	1.00 pound

year	building costs	operational costs	tolls	total	discount rate	discounted cash flow
1	-22,000,000	-800,000	2,372,500	-20,427,500	1.00	-20,427,500
2		-800,000	2,396,225	1,596,225	1.08	1,477,986
3		-800,000	2,420,187	1,620,187	1.17	1,389,049
4		-800,000	2,444,389	1,644,389	1.26	1,305,369
5		-800,000	2,468,833	1,668,833	1.36	1,226,642
6		-800,000	2,493,521	1,693,521	1.47	1,152,582
7		-800,000	2,518,457	1,718,457	1.59	1,082,919
8		-800,000	2,543,641	1,743,641	1.71	1,017,398
9		-800,000	2,569,078	1,769,078	1.85	955,778
10		-800,000	2,594,768	1,794,768	2.00	897,831
11		-800,000	2,620,716	1,820,716	2.16	843,344
12		-800,000	2,646,923	1,846,923	2.33	792,114
13		-800,000	2,673,392	1,873,392	2.52	743,950
14		-800,000	2,700,126	1,900,126	2.72	698,673
15		-800,000	2,727,128	1,927,128	2.94	656,112
16		-800,000	2,754,399	1,954,399	3.17	616,108
17		-800,000	2,781,943	1,981,943	3.43	578,510
18		-800,000	2,809,762	2,009,762	3.70	543,176
19		-800,000	2,837,860	2,037,860	4.00	509,972
20		-800,000	2,866,238	2,066,238	4.32	478,772

-3,461,214

