Teaching with a Scalable, Multidisciplinary Learning Object: A Business School Case Study

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ABSTRACT

This article describes a multimedia case study that was conceived as a high level learning object, reusable in different disciplines, and scalable in that it can be used for teaching at different levels in each discipline. Design principles for a reusable, scalable multidisciplinary learning object illustrate how the case study can be used in different ways. Use of the case for teaching MBA students about systems, IT infrastructure and network components, and frameworks for use by non-technical managers called on to make IT decisions is described. This description includes the learning goals, the lesson plan, and evaluation of the learning object and the lessons in which it was incorporated. The author concludes that use of the two design principles – separation of application from abstraction, and instructor-guided learning about abstraction – enabled production of a learning object that could be incorporated effectively in classroom teaching for MBA students in the core course.

Keywords: Learning object, scalability, reusability, evaluation, computer networks, decision making

1. INTRODUCTION

Teachers of the required information systems course in business degrees often lament the difficulty of motivating those students in the class to study a subject that is of little or no intrinsic interest to them. Much of the literature of information systems education is concerned with techniques for engaging and motivating such students.

One technique for engaging students is narrative or 'story telling' (Plowman, Luckin, Laurillard, Stratford, and Taylor, 1999). The classic form of narrative in management teaching is the context-rich case study, used with particular success by Harvard Business School. While there is a growing body of case studies in information systems, these tend to address managerial rather than technical lessons. Technical fields such as engineering do not yet have a tradition of narrative in teaching. Instead, they rely primarily on the solving of problems which are extracted from real-world contexts (Jonassen, 2004). Nonetheless, the success of narrative in fields such as mathematics (Papadimitriou, 2003) has attracted the attention of engineering teachers who need to prepare their students for a world in which they work with complex problems in real organizations.

The work described in this article draws on the joint efforts of teachers of information systems and information technology to business students and managers, and teachers of network operation and management to engineering students and technical staff, to develop a multimedia case study that could be used to teach about networks in a realistic business context.

Production of a case study, particularly a multimedia case study, can be a costly and time-consuming exercise, with economics more akin to the preparation of a chapter for a text book than a single class activity (Downes, 2000). It makes sense, then, to develop case studies that can be used in as many contexts as possible, at different levels of complexity, and even across disciplines. In this article, we describe how a multimedia case study can be conceived as a high level learning object and designed in such a way that it can be reused across different learning contexts; we describe an example of such a case study / learning object; and we describe how it was used successfully in teaching of non-technical MBA students in their information systems course.

2. DESIGN PRINCIPLES

The learning object was conceived as a case study in order to achieve the benefits of narrative in learning. In particular, we sought to involve students in the problems they would be directed by the teacher to solve, motivating them to address problems that they might otherwise consider too complex or too technical.

Two design principles were adopted to ensure that the case study could be used across different learning contexts (Klobas, Renzi, Giordano, and Sementina, 2004):

1) The principle of separation of application from abstraction.
2) The principle of instructor-guided learning about abstraction.

The elements of a lesson can be divided into an *abstraction* – the concept or idea to be taught, in its most general terms, and an *application* – the ability to apply the concept or idea to solve a given problem or in a given situation (Laurillard, 2002). Most learning objects combine abstraction and application, for example, by incorporating tests within the object (Cisco Systems, 2003). In the case study described here, the abstraction was omitted from the learning object, leaving the teacher responsible for abstractions, i.e. for guiding students to learn lessons that were appropriate to the field and level of study in which the lessons are to be learned.

3. THE CASE

The case study describes the problems faced by a company, New Tech, that has increased the size and complexity of its computer systems. Students are introduced to the organization at a time when the organization's network seems to have broken down completely and users are complaining "I cannot access …", "I cannot work".

The case is presented, in English and Italian in zipped format or on CD-ROM (available at no cost from the authors). It contains

1) A desktop environment which is accessed by clicking on the desired language of the opening screen. This environment delivers the case, using Macromedia Flash. Figure 1 provides an illustration of the environment. The case can either be run sequentially, from the window in which the case appears or by clicking on the name of the scene in the (collapsible) menu bar on the left hand side of the screen. The top area of the desktop provides buttons that allow the user to go back and forward among scenes, and to the Tools menu. A button on the lower right hand side of the screen enables the user to turn subtitles on or off (the default).

2) A computer-animated presentation of the case. Two members of the organization, the entrepreneur (Mr. Grande) and the IT officer (Mr. Fabi), present the problem to a newly appointed managing director (not named or seen on the screen, but the 'off screen' user of the case study, the person to whom Mr Grande is

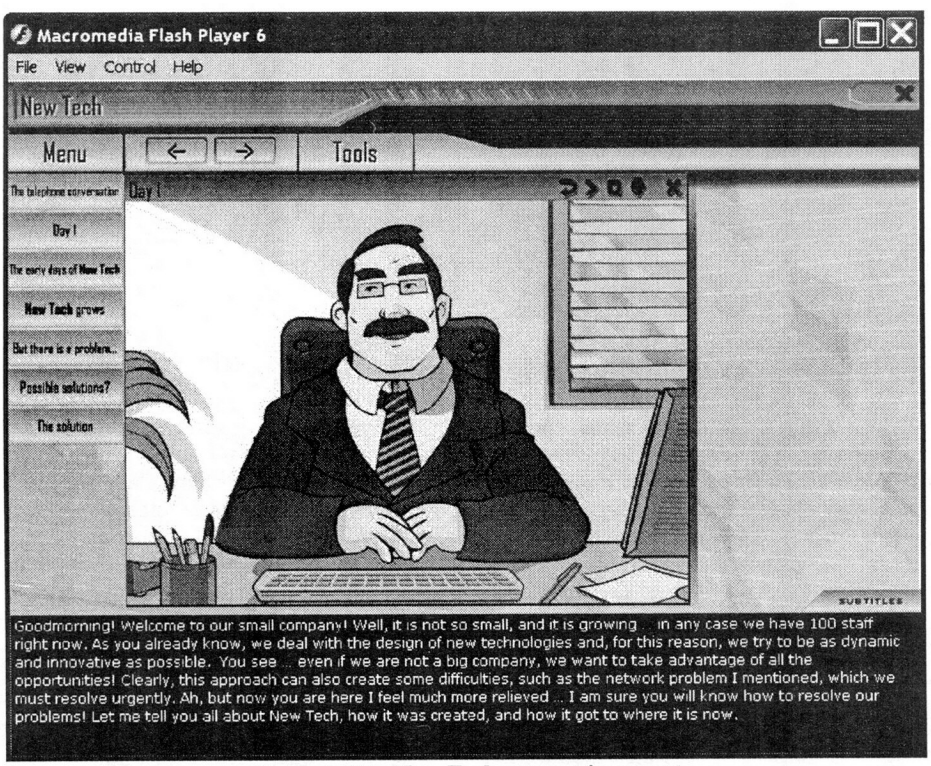

Figure 1. The New Tech case environment

speaking). The case is divided into seven 'chapters' which, taken in sequence, tell the 'story' of the case. The chapters are:

- The telephone conversation: A short opening chapter in which the entrepreneur tells the managing director (MD) about the problem and its urgency and invites him to meet to discuss it.
- Day 1: The meeting, on the MD's first day in the job. Mr. Grande introduces the company and expresses his hope that the MD will be able to solve the problem quickly.
- The Early Days of New Tech: The meeting is interrupted by Mr. Fabi, who brings news of more problems with the network. Mr. Grande invites Mr. Fabi to join the meeting and together they describe the early days of New Tech, how the Administration and Design divisions have always been in separate buildings, and how technology needs and provision have changed as the company has developed. The accompanying animations illustrate changes in the type of computer and network used, from mainframe and terminals to the current internetworked client-server arrangement spread across two buildings and accessible to the firm's clients through the Internet. Each different type of device (mainframe, terminal, workstation, server, client, local area network, router) appears on the screen as it is named, telling the history of development of computers in an engaging manner. Figure 2 illustrates the animations.

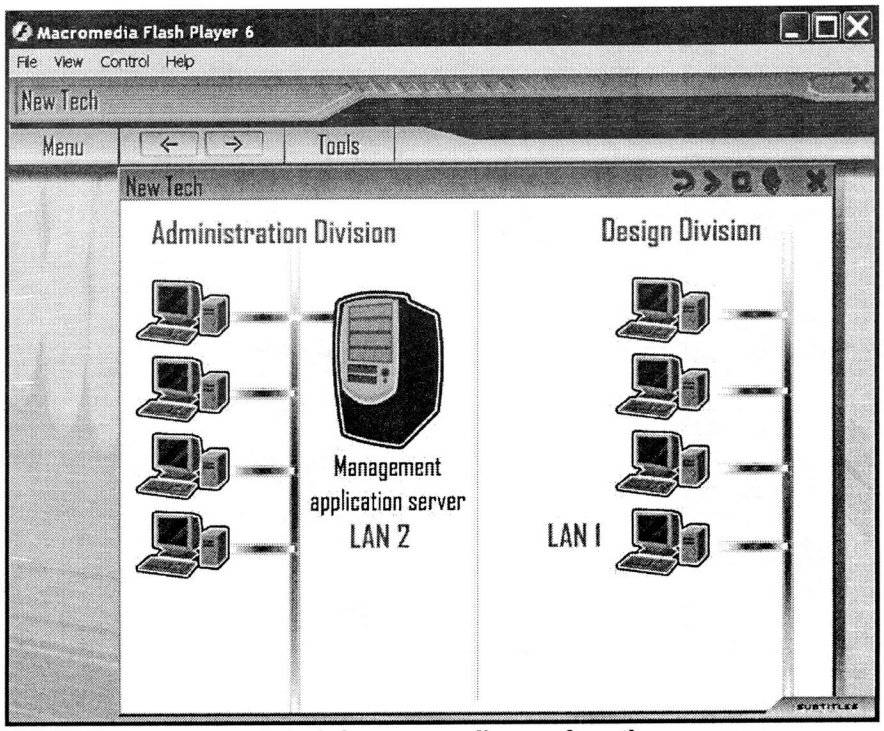

Figure 2. An infrastructure diagram from the case

The language used in these descriptions is designed to be suitable for students who have not previously studied information technology. Where illustration is insufficient to explain a term, e.g. router, a brief non-technical description is given in conversational terms by Mr. Fabi.

- New Tech Grows: The company now offers e-learning solutions to train its clients in use of its products. This chapter describes how the company employed e-learning experts to develop solutions. Having observed the success with their clients, New Tech decided to introduce e-learning for its own staff, to help them develop skills necessary for dealing with New Tech's increasingly international business. An e-learning server, and most recently, dedicated e-learning workstations, were added to the Design LAN. The changes to the infrastructure are described and illustrated.
- But there is a problem: Mr. Grande describes how suddenly staff and clients started to have access problems. Mr. Fabi describes the four suppliers that New Tech uses: GestiSoft for management applications and the Administration LAN (LAN 2 in the illustrations), TechSoft for the technical and design applications and the Design LAN (LAN 1 in the illustrations), Telecom for the data transmission line (and routers) that connect the two buildings, and Super Learning, for the e-learning platform. A screen shows a table on which a brochure for each company is displayed. Introductory text for each company is displayed by clicking on the cover sheet.
- Possible Solutions: Each supplier was invited to check the system and propose a solution. Each proposal is described briefly by Mr. Fabi and illustrated with animated changes to the current

infrastructure. The closing screen offers a link to the reports provided by each supplier. By clicking on the link, the user opens a Microsoft Word file which contains the report. Each report contains a summary of the situation as the supplier understands it, the supplier's technical diagnosis of the problem as it affects the components they supply, their proposed solution, and its costing. Although the students are not advised of this, none of the proposed solutions actually addresses the real problem which is that the network traffic generated by the new e-learning systems is interfering with TCP transmission across the company's Ethernet LANs. Instead, each vendor proposes an upgrade to the latest versions of the components that they already have installed in the company.

- The Solution: In the final chapter, Mr. Fabi introduces the solution proposed by a systems integrator, ExpertNetwork. The solution is available by clicking on the cover of the report. The solution notes that the problem arose simultaneously with the expansion of use of e-learning and presents an analysis of traffic across the system. The final recommendation is to use an inexpensive switch to isolate intensive e-learning traffic in a sub-network on the Design LAN. This is the technical solution to the problem. Business students may not, however, be required to solve the technical problem. The solution for business students may simply consist of recognizing that a system integrator or consultant should be called in.

The animation (without the solution) runs for eight minutes if played in sequence.

3) The suppliers' technical proposals. The proposals were produced by four real suppliers: a telecommunications service provider, and providers of networking, hardware, and software solutions. They included observations on the technical state of each component of the IT infrastructure, prepared in simulations run by network engineers at Pisa University using the real network data and NS2-NAM simulation software available from http://www.isi.edu/nsnam/nam.
4) The final solution, prepared by a systems integrator, ExpertNetwork, and accessed in Word from within the case. This solution includes screens produced by the NS2-NAM simulator. The simulation of backbone traffic is shown in Figure 3. This is, of course, the final solution to the immediate problem. The organization has no IT management practices in place, and would also benefit from longer term solutions such as an IT architecture and perhaps a more formal IS support structure. Teachers may direct business students to consider this longer term solution.
5) Links to tools that provide more information about computers and networks, or rapid access to case documents:
   - A glossary of 15 technical terms included in the case.
   - A link to tutorials on networking, principally Furdyk (2004).
   - Quick access to the network maps for each supplier's proposed solution.
   - Quick access to all the Word documents included in the case disk.
   - Links to web-based encyclopedia of technical terms ('External Resources').
   - Information about the case, its goals, the contributors, and contacts for additional information.

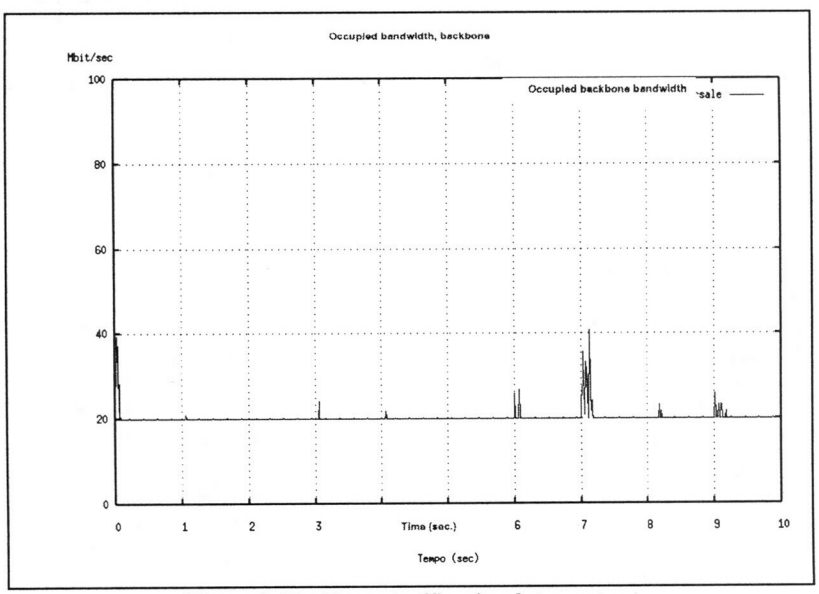

Figure 3. Backbone traffic, simulator output

All linked documents in the case open as Word documents through the default browser (either Internet Explorer or Netscape).

3.1 Student roles

Students may play one of several roles as the case is solved: the new MD, the technical support staff, a provider representative, or the representative of an independent systems integrator or consulting firm. The role or roles played depend on the goals of the teacher. For example, all roles might be included in a group role play designed to help students understand the different roles of different players in the IT industry when an organization seeks to solve a problem. This section will, however, concentrate on the most common situation, when each student plays the role of the MD.

3.2 Learning goals

The case was designed to enable teachers in different disciplines at different levels to extract different lessons. Those identified at the time of design are shown in Table 1. The first three levels are relevant to all disciplines, and can be studied by technical and non-technical students alike. The final two levels are specific to network engineering students or others working to configure networks (level 4), and to business students or decision makers (level 5).

Level	Learning Goal	Target Learners
1	Understand the nature of a system	All
2	Understand how a network functions as a system	All
3	Identify the components of a TCP-based network, and how they fit together	All
4	How to configure a network	Technologists
5	How to evaluate advice that has implications for real networks	Business students/decision makers

Table 1. Learning goals and target learners

Working with business students in the classroom, the case writers identified a more detailed set of possible learning objectives for non-technical business students. These are listed in Table 2.

3.3 Presenting the case to students

The case may be used either to reinforce an earlier lesson on network infrastructure or as a way to stimulate students to undertake independent research about IT infrastructure. In the second situation, the students are encouraged to use the tools (glossary, tutorials and links to web-based encyclopedia) to fill in the gaps in their IT knowledge. This is more likely to be effective for students who already have some motivation to learn about IT than for those business students whose motivation or self-efficacy for learning about technical subjects is low. We therefore recommend using the case without a prior lesson on network infrastructure only with technically inclined students.

1	Identify the primary components of technical IT infrastructure. Be able to interpret a typical business configuration and describe the role of each component within it.
2	Understand, and describe, how a network functions as a system. Recognize the need to analyze across the entire system – and the difficulty of doing this.
3	Learn how to use a template for structured analysis of IT problems: Current situation, Situation analysis (resources or parameters to evaluate, a reference standard for each, the current version or performance of the installed system), Proposal solution, Costing of proposed solution.
4	Learn how to evaluate proposals: the language used in offers; different terms used by different suppliers to describe the same elements of the system; the need to ask questions to clarify; the self-interested nature of suppliers' benchmarks, analyses and offers; do we always need the latest version?
5	Understand the structure of the IT industry: hardware, software, network, and service providers; the role of vendor-independent system integrators in IT decisions.
6	Recognize the role of outsourcing in system design, provision, and operation for modern organizations
7	Learn strategies for non-technical managers faced with IT decisions.
8	Learn techniques and identify sources that enable independent learning about information technology.

Table 2. Learning objectives for business students

A version of the case without the final solution can be worked on by students outside of class. Alternatively, it may be presented to the students in the classroom.

When the case is presented in the classroom, the teacher shows the case (without the solution) sequentially. If the students are non-technical, the teacher may stop and answer questions as the case is shown, although in practice we have found little need to clarify. The links to extra resources are written on the board or given to the students in a handout.

The students are then asked to solve the problem, either alone or – the case writers' preference – in groups. In the case, Mr. Grande says to the GM, "I would like you to go through these proposals, and try to identify the right one as soon as possible." The best solution is not one of those presented, so it is important for the teacher to reassure students that Mr. Grande is expressing his desire to have a solution as soon as possible, but the MD is free to find the best solution that meets the company's needs without necessarily choosing from exactly what has been offered (he is, after all, the MD).

If the students work in groups during class time, they are given one to one and a half hours to make and document

their decision. One hour provides just enough time to compare the solutions and make a decision, but does not provide enough time to research or share knowledge about the technology. In-class group work is most appropriate for reinforcing earlier technical lessons and learning the business lessons listed in Table 2 (objectives 1-7). Out-of-class group work is the best way to ensure that students have time to research technical issues.

The case solution is presented in the classroom. The case writers recommend that the first stage of case solution is a vote, where votes can be cast for: a specific supplier's solution, a mix of solutions drawn from different suppliers, or a different solution altogether. Voting can take 5-15 minutes depending on the number of students in the class.

Presentation of the solution requires about 15 minutes. The time taken for a synthetic overview of lessons learned depends on the specific abstractions that the teacher plans to draw, but the case writers normally allow 30-60 minutes for this final stage.

4. LEARNING FROM NEW TECH: A CASE STUDY

In this section, we present an example of how the case has been used in MBA classrooms with non-technical business students taking their only course in information systems. The information provided here is pooled from experience in two classrooms, both working in English: one classroom in Europe, with 51 students from 20 different countries representing all continents except Australia, and a small classroom of 5 Australian students. Only a very small number of these students, 3, had studied information systems at university. Most were aged between 23 and 27, although the Australian students were older and had more work experience.

4.1 Learning objectives

The teachers emphasized learning objectives 1, 2 and 7 from Table 2. They were expressed as:

- Identify the primary components of technical IT infrastructure. Be able to interpret a typical business configuration and describe the role of each component within it.
- Understand, and describe, how a network functions as a system.
- Learn to use the reflective learning cycle and personal protocols as frameworks for managing decision making about IT.

These are directly related to learning goals 1, 2, 3 and 5 from the higher level learning goals for which the case was designed.

4.2 Presenting the case to students

Two one and a half hour lessons were devoted to the lessons associated with this case. Students were also asked to meet in pre-defined groups of five for 1-2 hours outside of class time, and encouraged to use the tools provided with the case study for further clarification of technical questions. At the end of the second class, they were given an assessable 'homework' exercise designed to reinforce the lessons learnt.

The first lesson consisted of a lecture on the hardware and network components of IT infrastructure. (Students had already attended lessons about the nature of information systems, the components of IT architecture and infrastructure, computer architecture, and software.) The case was presented during the last half hour of the class. The animation was shown, and students were given the instruction sheet that appears in Appendix 1. As stated in the instruction sheet, they were required to collectively take the role of the new MD and prepare a brief presentation (equivalent of 2-4 PowerPoint slides) in which they describe and explain their proposed solution. The presentation served as a summary of group deliberations, it was not for submission or assessment. Before the first class ended, the students were given time to decide on a group strategy and ask clarifying questions.

The second class began with votes for the options listed in the instruction sheet. Each group had one vote. All 11 groups voted for a solution that combined the vendors' proposed solutions in some way. The most common group proposal was to adopt all of the proposed solutions, although some groups selected elements of different vendors' proposals based on their assessment of the potential for the recommendation to improve network functioning.

After the votes and group proposals were discussed for about 15 minutes, the solution was presented (15 minutes, including discussion of technical issues associated with the ways in which the TCP and UDP transmission protocols behave when they are present on the same Ethernet segment). The rest of the class, apart from 10 minutes when students completed evaluations of the case study for research purposes, was devoted to drawing lessons from the case.

The final IT infrastructure drawing provided by the system integrators, ExpertNetwork, was used to review the components of IT infrastructure and how they are combined in a typical business configuration. Students were then introduced to two techniques that non-technical (and technical) business managers can use when faced with technical decisions: the reflective learning cycle and personal protocols.

4.2.1 The Reflective learning cycle: The problems confronted by a business manager who is required to make a technical decision or an informed contribution to a technical decision have many parallels with the problems that Schon (1983) identified in the professions some 20 years ago. Managers are often required to make decisions about complex issues whose resolution requires access to broader knowledge than any one individual manager has. A partial solution is to engage members of a decision making team, as in the case. But, whether in a team or as an individual, decision makers benefit from using a framework that guides analysis and decision making. Schon's reflective learning cycle (RFC) was adopted as the framework to be taught to students in these classes. The RFC was illustrated by the diagram shown in Figure 4.

The first stage is accurate observation. In the case, two types of observation were available: temporal and technical. Temporal observations could have been made by all students (although surprisingly few did this): the event that immediately preceded the problems with network access was the expansion of e-learning due to the addition of new, dedicated e-learning workstations to the network. The technical observations can be taken directly from the suppliers' reports. Students were also encouraged to check all terms used in the reports and ensure they understood them as part of observation.

Once observation is complete, connections between the observations can be made. At this stage, the real problem – as distinct from the symptoms – can be defined. This is the reflective stage of the cycle. In the New Tech case, reflection shows that there is a connection between the expansion of e-learning and the failure of the network. It also shows that there is no connection between the suppliers' proposals and resolution of a problem that connects e-learning with the network.

Actions are proposed and tested during the planning stage. Decision constraints are taken into account. Some students incorrectly assumed that New Tech would want to resolve the problem at low cost, even though no mention of containing costs is made in the case. Instead, time is the over-arching constraint in the case. Having identified constraints, a solution can be proposed. In this case, the first step in the solution was to call in the systems integrator, ExpertNetwork. To reinforce their learning of the technical issues, the students were also guided to incorporate the technical solution proposed by ExpertNetwork. Students were encouraged test the plan by asking how the proposed solution will address the symptoms observed at the observation stage of the cycle. (Engineering students would be asked simulate the solution.)

The final stage of the cycle is implementation. Since this is an iterative cycle, the results of the implementation are observed and the cycle continues.

To test their understanding of the RLC, and to review the technical knowledge they had gained from the case study, the students were required to complete an RLC for the technical 'solution' to the New Tech case. They submitted this for assessment.

4.2.2 Personal protocols: Students were each asked to write 1-2 'golden rules' that encapsulated best practice for non-technical managers faced with making technical decisions. They were then shown the lecturer's set of such rules. Together, the rules form a Personal Protocol for IT decision making. A sample Personal Protocol appears in Table 3.

Students were required to develop a complete personal protocol (5-10 rules) as assessable 'homework'.

4.3 Student response to the case study and lessons

The case was evaluated on the basis of

1) students' overall evaluation of the case
2) student perception of the technical quality of the case
3) student attitude to the case study as a learning experience
4) self-reported learning as a result of using the case
5) actual learning of the lessons described in the learning objectives, as demonstrated in examination scripts

All but the last of these evaluations was obtained by administering two questionnaires in the classroom. The first questionnaire addressed the first two levels of evaluation, and was handed to students at the end of the class in which the case was presented. The second questionnaire, addressing the next two levels of evaluation, was handed out toward the end of the second class. Thirty-six valid responses were received.

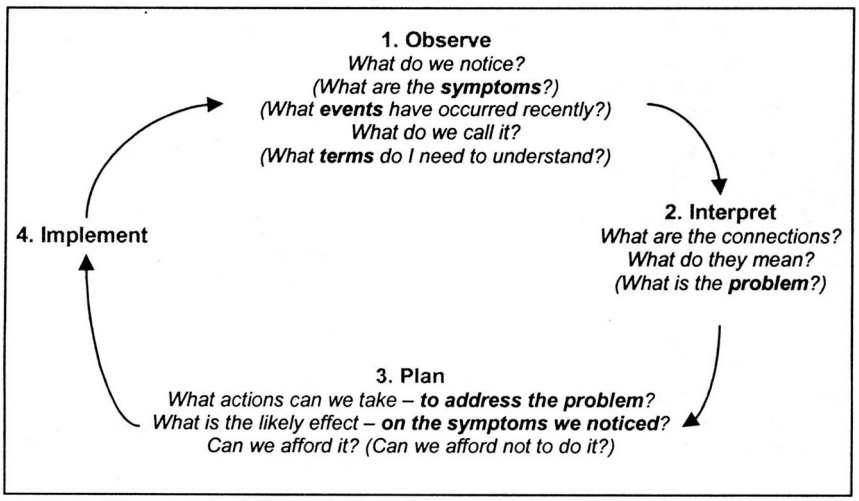

Figure 4. An interpretation of Schon's reflective learning cycle

1) Ask questions. ▪ If I don't know what blah-blah-blah means, ask. It is more embarrassing to make a bad decision than to ask a simple question. 2) Understand the problem as well as possible. ▪ Use the RLC to identify symptoms (and, if possible, the problem that causes them), and to check that proposed solutions address the symptoms (and therefore the problem). 3) Do some research. ▪ Check out the state-of-the-art in managing these issues, from books, articles, and the Internet 4) Don't hesitate to call for independent advice. ▪ From a phone call to a friend to a systems integrator's report. 5) Check ALL solutions against my analysis of the symptoms and problems ▪ Check that the recommendations actually address the symptoms/problem. ▪ If in doubt, ASK MORE QUESTIONS 6) Have courage! ▪ Perfect information is impossible (for all management decisions!) 7) Work in a multi-disciplinary team whenever possible. ▪ Few problems of this kind can be solved by technical or managerial staff alone. The organization is a system!

Table 3. Sample Personal Protocol for IT decision making

4.3.1 Overall Evaluation of the Case: Students were asked "Please write three words or phrases that summarize your first impression of this case study". Thirty percent of the 85 remarks made referred, non-evaluatively, to case characteristics such as "tests technical knowledge", "complex" or "challenging". The rest of the comments were evaluative. Eighty percent of these were positive. The case was described most frequently as "interesting" or "intriguing" (12 students), "good" (9), "realistic" or "meaningful", "fun" or "enjoyable", "useful" (5 students each) or "informative" (4). The most frequent negative remark (5 students) was that a clearer definition of the problem was needed. Since the students were required to define the problem in this case, this criticism points more to the way the case is introduced to students rather than the case itself. In their introduction to the case, teachers should pre-empt students' possible sense of disorientation by noting that, in this business case, part of the MD's role is to define the problem.

4.3.2 Technical Quality of the Case: Students were asked to rate 30 aspects of the technical quality of the case on a scale from 1 *not at all* to 10 *completely*. At the same time, they were asked to indicate the importance of each rated quality using the same scale. The list of items is in Appendix 2. The most important qualities for these students were: the clarity of the voices, both in terms of the English spoken by the characters and a lack of background noise or disturbance; the realism of the case (organizations face problems like that presented in the case); the informativeness of the network graphics; and that the case is interesting and entertaining. The case performed well on all these characteristics. Ability to entertain was slightly below expectations but still above the mid-point of the scale indicating that the case was more entertaining than not. There was a slight preference for videotape over computer animated characters, but there was high variation in responses, and this was not a particularly important factor for the students. Overall, we can conclude that the case is clear, realistic, informative, and moderately entertaining as well as interesting.

4.3.3 The Case Study as a Learning Experience: In the second questionnaire, the students were asked to rate "using the case study to learn about networks as part of my course" on 12 semantic differentials. The semantic differentials and scores appear in Appendix 3. While the measures already discussed addressed the case study as learning object, this evaluation concerned the lesson that used the case study and therefore incorporated evaluation of the instructors' abstraction of lessons as well as the case study itself. The learning experience was rated as valuable, helpful, informative, a good use of time and interesting, although a little dull.

4.3.4 Learning from the Case: Two indicators of learning were used: students' self-reported learning, and examination results. Sixteen items, listed in Appendix 4, were used to measure self-reported learning. Fourteen items referred to technical lessons, while two referred to business lessons. The examination included one multiple choice question and one (optional) essay question.

On the self-report scale, students were asked to indicate "How much you feel you knew about this topic before commencing the case study" and how much they felt they knew after completing it on a scale of 0 *nothing at all* to 10 *everything (I am an expert)*. Self-reported learning, included in Appendix 4, was scored as the difference between the two values. Increases of a point or more were reported for all items. Some of the biggest gains in learning were recorded for the most technical topics, where initial knowledge was low: the role of a switch to improvement network throughput and scalability, and how a router differs from a switch. Other significant gains were in the two business areas, evaluation of suppliers' proposals for IS upgrades and the role of a systems integrator, and in 'softer' technical knowledge, how to interpret an IT architecture (or infrastructure) diagram, and how the components of a computer-based network interact with one another in a system.

Exam results confirmed that learning about both technical and business issues had occurred. More than 60% of students, ranging from those with no prior IS background to a systems engineer, chose to answer the examination question relating to the case. Scores on the question ranged from 1.5 (insufficient) to 5 (outstanding) with a median of 3.75 and mode of 3. The distribution of marks for this question was consistent with that for the other question based on an activity that involved group work, and higher than that for questions that had not involved group work. We can

conclude, then, that student learning from use of this case study was as effective as learning from other group activities.

5. CONCLUSIONS

The two principles, separation of application from abstraction, and instructor-guided learning about abstraction, guided development of a case study that enabled MBA students to learn about network architecture and IT decision making. In classroom use, students responded well to the case itself, before they were introduced to the abstractions (lessons). Following introduction of the abstractions, the students responded positively to the case and to their learning from it. The instructors' assessment of learning was very positive, with students performing well on examination tasks associated with lessons reinforced by, and drawn from, the case.

The approach taken in development of the case demonstrates that effective learning objects need not include abstractions or tests associated with abstractions. Indeed, a better use of funds available for multimedia case studies may well be to develop abstraction-free objects such as that described in this article. Objects of this kind can be re-used across disciplines and for learners at different levels.

The effectiveness of learning with this type of object rests on the ability of the instructor to plan engaging lessons from which students learn. But, this is as it should be. The way in which any learning object is incorporated in a course affects its contribution to learning. Abstraction-free learning objects provide instructors with greater flexibility in drawing lessons. The quality of the lessons drawn quite rightly depends on the quality of the instructor's lesson plan.

6. ACKNOWLEDGEMENTS

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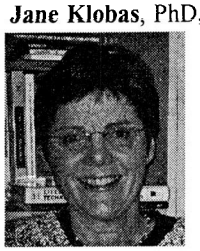

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APPENDIX 1: NEW TECH INSTRUCTIONS TO STUDENTS

IT infrastructure decisions: The New Tech case

The case

New Tech is a high-tech design company that employs about 100 people in two different locations. Members of staff are experiencing computing problems that are so bad that they have begun to complain, not only to the IT manager Mr. Fabi, but also to the chairman and owner, Mr. Grande. On your first day of work as the new Managing Director of New Tech, you are called on to resolve the problem!

The problem is presented in a series of animated films that are illustrated with diagrams of the company's IT infrastructure. Four vendors have been asked to propose solutions; Mr Fabi will introduce the vendors and provide you with a summary of their proposals.

The case materials consist of:

1. The New Tech animated films. We will show these films in the classroom.
2. The text of the words spoken in the films. These are available in the online zip file.
3. Mr. Fabi's summary of the vendor proposals. These are available in the online zip file.
4. These instructions.

Your task

Recommend what action to take. You can select one or more of the proposals to implement, or suggest another course of action. Prepare a brief presentation (2-4 slides) that describes and explains your solution.

When we meet in class, each group will be asked to vote for one of the following recommended courses of action:

A1	Accept Gestisoft's recommendation.
A2	Accept some, but not all, elements of Gestisoft's recommendation. (Be prepared to describe what you would accept and what you would reject, and explain your choices.)
B1	Accept Techsoft's recommendation.
B2	Accept some, but not all, elements of Techsoft's recommendation. (Be prepared to describe what you would accept and what you would reject, and explain your choices.)
C1	Accept Telecom's recommendation.
C2	Accept some, but not all, elements of Telecom's recommendation. (Be prepared to describe what you would accept and what you would reject, and explain your choices.)
D1	Accept Superlearning's recommendation.
D2	Accept some, but not all, of Superlearning's recommendation. (Be prepared to describe what you would accept and what you would reject, and explain your choices.)
E	Adopt a combination of the recommended solutions. (Be prepared to describe and explain your proposed solution.)
F	Take another course of action. (Be prepared to explain what you would do, and why.)

The objectives of the exercise

1. Consolidate your knowledge of the components of IT infrastructure, and network infrastructure in particular.
2. Examine how the components interact with one another as a system in which a change in one element affects the whole.
3. Learn how to use some specific techniques that can assist non-technical managers faced with IT decisions.

APPENDIX 2: EVALUATION OF TECHNICAL QUALITY

Quality	Quality[a]		Importance[a]	
	Mean	s.e.[b]	Mean	s.e.
The English spoken by the characters was clear and understandable	8.4	.4	8.0	.5
I could hear clearly the voices that speak during the case	7.6	.5	7.8	.5
The information provided in the case is interesting	7.5	.3	7.2	.4
I believe that organizations face problems like the one presented in the case	7.4	.3	7.7	.3
The network graphics are informative	7.0	.4	7.4	.4
I believe that suppliers prepare reports like those included in this case	6.8	.4	7.0	.4
The roles that the characters are playing in the case are realistic	6.8	.5	6.8	.4
The case presentation is entertaining	6.6	.4	7.1	.3
The information provided in the case is accurate	6.3	.7	6.8	.3
I would prefer a videotape of real people to the animated representation of characters used in this case	6.3	.3	5.4	.8
The graphics could be more informative	6.3	.5	6.4	.5
I do not like the way the characters move	6.1	.5	4.2	.6
The information provided in the case is not up to date	5.7	.6	6.7	.6
It was easy to be distracted by other things while I was reviewing the case materials	5.7	.5	6.6	.4
The characters' voices are good	5.3	.4	4.8	.7
I had trouble reading the diagrams included with the case	5.3	.6	6.7	.4
The suppliers' reports do not seem realistic to me	5.2	.6	6.6	.5
I would not like to meet the IT officer, Mr. Fabi	5.1	.6	4.2	.7
The graphical representations of the characters are not appropriate to the roles they are playing in the case	5.1	.7	5.5	.6
The characters' voices are appropriate given the roles they are playing in the case	5.0	.6	4.8	.7
The quality of the graphics in the CD-ROM is low	5.0	.5	4.4	.5
This CD-ROM does not represent a real case	5.0	.4	6.2	.7
The problem presented in the case is not real	5.0	.6	6.1	.5
I would like to meet the owner, Mr. Grande	4.9	.6	4.7	.7
I like the way the characters are graphically represented in the case	4.9	.4	4.4	.5
The case disk does not contain much useful information	4.8	.6	6.5	.6
I do not like the way the characters are portrayed in this case	4.7	.6	5.1	.6
The synchronization of character movements and voices is poor	4.5	.5	4.2	.6
The quality of the voices is unclear and marred by background noise or disturbance	4.1	.5	5.8	.6
The synchronization of voices with graphics is adequate	4.1	.7	6.0	.5

[a] from 0 *not at all* to 10 *completely*. [b] Standard error.

APPENDIX 3: SEMANTIC DIFFERENTIALS FOR EVALUATION OF LEARNING EXPERIENCE

	Score[a]		
	Mean	s.e.	
worthless	5.1	.2	valuable
unhelpful	4.9	.2	helpful
uninformative	4.8	.2	informative
a waste of time	4.7	.2	a good use of time
boring	4.2	.2	interesting
fun	4.0	.3	dull
unexciting	3.8	.2	exciting
enjoyable	3.8	.2	unenjoyable
pleasant	3.5	.2	unpleasant
useful	3.4	.2	useless
good	3.1	.2	bad
it helped me to learn about networks	2.9	.2	it did not help me to learn about networks

[a] Scale is from 1 (left side) to 7 (right side)

APPENDIX 4: SELF-REPORTED LEARNING

Topic	Learning score[a]	
	Mean	**s.e.**
How can a switch be used to improve network throughput?	2.7	.4
How can a switch be used to enhance network scalability?	2.5	.4
What is the difference between a switch and a router?	2.2	.3
How to evaluate suppliers' proposals for IS upgrades	2.1	.3
What is the role of a 'systems integrator'?	2.0	.4
How to interpret an IT architecture (or infrastructure) diagram	1.9	.3
How do the components of a computer-based network interact with one another in a system?	1.7	.4
What is network bandwidth?	1.6	.3
What is the relationship between a client computer and a server?	1.5	.3
What does a router do?	1.5	.3
How a Virtual Private Network (VPN) can be used to connect two locations in a corporate network	1.5	.4
What is a LAN?	1.3	.3
What is a system?	1.3	.2
What is a workstation?	1.1	.2
What does a server do?	1.1	.4
What is the throughput of a network?	1.0	.3
[a] See text for method of calculation		