Digital Simulations for Improving Education:
Learning Through Artificial Teaching Environments

David Gibson
University of Vermont, USA

Youngkyun Baek
Korea National University of Education, Republic of Korea

INFORMATION SCIENCE REFERENCE
Hershey · New York

Director of Editorial Content: Kristin Klinger
Director of Production: Jennifer Neidig
Managing Editor: Jamie Snavely
Assistant Managing Editor: Carole Coulson
Typesetter: Michael Brehm
Cover Design: Lisa Tosheff
Printed at: Yurchak Printing Inc.

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue, Suite 200
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

and in the United Kingdom by
Information Science Reference (an imprint of IGI Global)
3 Henrietta Street
Covent Garden
London WC2E 8LU
Tel: 44 20 7240 0856
Fax: 44 20 7379 0609
Web site: http://www.eurospanbookstore.com

Library of Congress Cataloging-in-Publication Data

Digital simulations for improving education : learning through artificial teaching environments / David Gibson and Youngkyun Baek, editors.

p. cm.

Includes bibliographical references and index.

Summary: "This book is for anyone who is looking into games and simulations with an eye to their potential for improving teaching and learning"--Provided by publisher.

ISBN 978-1-60566-322-7 (hardcover) -- ISBN 978-1-60566-323-4 (ebook)

1. Simulated environment (Teaching method) 2. Simulation games in education. 3. Computer games. I. Gibson, David, Ed. D. II. Baek, Youngkyun.

LB1029.S5D54 2009

371.39'7--dc22

2008035142

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Chapter VI
The Narrative Event Diagram:
A Tool for Designing Professional Simulations

Helyn Gould
University of Strathclyde, UK

Michael Hughes
University of Strathclyde, UK

Paul Maharg
University of Strathclyde, UK

Emma Nicol
University of Strathclyde, UK

ABSTRACT

Game-based learning and simulation is a powerful mode of learning, used by industries as diverse as aviation and health sciences. While there are many generic Virtual Learning Environments available to further education and higher education in the United Kingdom, there is no widely available open-source Web-based simulation environment for professional learning. The SIMPLE (SIMulated Professional Learning Environment) project has designed, created, implemented and is in the process of evaluating such an environment in a range of disciplinary settings. The simulations that are being created place both undergraduates and postgraduates in a professional context where their work is, as it will be in the workplace, distributed between tools, colleagues, resources, anticipated, and unanticipated problems. One of the key tools that staff will use to create simulations is the "narrative event diagram", a design tool as well as a means by which the narrative of the simulation is constructed. This chapter will describe the tool, its design history and context, its current use, and next design iteration. In particular it will show the interdisciplinary genesis of the tool's design, arising from the confluence of computer science, information science, and narrative theory, and its power in designing professional educational simulations.

INTRODUCTION

Simulation-based training, particularly as defined by Gredler (1996) has been shown to be highly effective in professional disciplines. It is true of professions where work is highly governed by protocol and procedure, for instance simulator training for pilots; and also in professional situations where ill-structured problems arise, and where affect and knowledge are key components of professional practice (Duffy and Cunningham, 1996; Bloxham and Armitage, 2003; Forrest et al., 2002 & 2003; Blackburn et al., 2003). In one study, nurses were taught to treat critically ill hospital patients *via* mini-lectures, workshops and simulator-based patients. The subject matter included digital assessment of respiratory, cardiovascular and renal systems, and pain management. Participants completed pre- and post-course tests, which showed statistically significant improvement; in the follow-ups at two months and six months later, participants reported long-term confidence in caring for acutely ill patients (Stedeford et al., 2003; Maharg, 2007a). Two general points can be made about this and related studies. First, the simulator-based patients were used to assess not only patient-handling skills, but also medico-scientific knowledge. Second, as an educational approach, simulation was used to enable students to learn the synthesis of skills and knowledge they would use in the workplace; but it was also used to assess that synthesis.

The key question for anyone interested in implementing such approaches is: how can educators most effectively create simulations of complex professional procedures? This chapter describes the methods adopted by the SIMPLE project (SIMulated Professional Learning Environment) to enable academic staff to visualise, design and implement complex simulations of professional procedures across a range of disciplines and professions. We begin with the context of simulation use, describing the background to the SIMPLE project, its objectives and audience. Next we shall describe the development of one of our critical tools, the Narrative Event Diagram (NED), from a technical perspective. We shall then analyse aspects of its use and effectiveness when deployed by academic staff, and discuss possible future uses of the method that combines simulation with ongoing professional development.

CASES VS. SIMULATIONS

Cases or case studies are commonly used within the fields of Law, Medicine and Business. Harvard University in particular has embraced this approach to teaching and learning, sharing its cases with the wider academic community (Christensen, 1987; DeLacey & Leonard, 2002). A detailed but unstructured description of the professional case is presented to the student. Information is included but some structuring and analysis is required to 'make sense' of the situation. The role of the academic here changes to that of advisor and facilitator, while the student must actively participate to move the case forward.

Cases have proven to be effective vehicles for professional learning but have two principal drawbacks. The first drawback relates to the nature of the information provided for the student. The case has to be distilled and presented to the student, frequently in text form. The information then becomes static. The professional environment however, is dynamic in nature, as indeed is knowledge itself; it does not stand still while we work (Callon & Latour, 1981). The static aspect of a case study reduces the student's need to explore, direct, gather, dialogue and synthesize the case. Students are usually only able to explore this problem space through interaction with peers or tutors (though other learning aids may be used). At this point the second drawback appears. The use of role-play goes some way to address issues of interactivity, but often has significant resource implications. The resource implications of case-based learning are significant and correlate directly to the level of interaction involved in the replication of aspects of reality (Wolfe and Guth 1975). Role-play, while educationally effective, can be particularly time consuming, creating logistical constraints on the number of students that can be involved in a case at a given time.

A possible heuristic alternative to case studies is project work (Kilpatrick, 1918; Stenhouse, 1983; Wolff, 2002. Where case studies are not employed in depth, the project is often the closest that most students come to the reality of practice during their education. Whether individual or group, live projects allow students to not only apply their knowledge of theory but to develop professional skills and deepen their understanding of process issues too. However, the tradeoffs are significant and familiar to most academics. The management of multiple projects can be extremely time consuming and project generation carries a high level of uncertainty from a planning perspective and requires the commitment of external personnel in addition to significant internal resource.

One technical approach to the re-enactment of aspects of reality is through simulation. For a learner, simulations should provide a "safe", controlled environment in which they can explore the problem/scenario and try alternative approaches. Aldrich (2007) and Dickey (2005) have explored a number of ways that a simulation can be constructed in order to accommodate this. Engagement in the learning process is essential, and is often achieved by treating simulation as a narrative, where interactive design and complexity is planned into the iterations of the decisions that players must make within the simulation (Gee, 2003; Li and Baihlie, 1993). The elements of active choice and reflection (or as Gee (2003, p.90) puts it, 'the probe, hypothesize, reprobe, rethink cycle'), together with opportunities for a wide variety of feedback methods and assessment give simulation its uniquely powerful protean capacity to support learning. Without these traits, simulation can become merely a different vector for traditional question-answer type activity.

Within a simulation, teachers construct a problem space in which the learner can be left to explore a scenario and this exploration process forces the learner constantly to evaluate and then re-evaluate their approach. It is not necessary that final achievement is a "success" state; the choices that a learner makes reflect their learning, as opposed to the final product. Process can be prized in addition to, or as an alternative to, end states.

Some of the advantages of simulation exist on the administrative side:

- real-time (or remotely) learner's progress and achievements.
- re-use
- asset management
- choice of co-operative, adversarial or solo "play" modes (Aldrich, 2005)

Partly as a result of simulation's rule-based structures, teachers (and institutions) have a "write once, play many" resource. This means that investment in the creation of a simulation can be recouped by re-using the simulation with alternative parameters to provide a different learning experience, e.g. different outcomes, different difficulty, whilst not having a substantial re-investment, although there would still be recurring costs to be handled: staffing, any physical resources required to run the simulation, etc. The issue of 'administrative cost' is an important one. Often this is the chief barrier to the adoption of innovative technology within teaching (Ball & Thornbury, 2004). Simply put, how much does it cost in terms of time and resources of the academic?

SIMPLE: PROJECT BACKGROUND

For the past seven years in the Glasgow Graduate School of Law (GGSL), we have used simulations on the postgraduate Diploma in Legal Practice. This program, delivered in five centers through-out Scotland including the GGSL, is overseen by the Law Society of Scotland and is compulsory for anyone who wishes to become a solicitor or advocate in Scotland (the approximate equivalent of an attorney in the US). It is effectively a bridging course, between the undergraduate and highly academic LLB program (as the typical undergraduate law program is termed in Scotland), and the two-year traineeship with a legal service provider that follows the Diploma. Successful completion of the Diploma leads to the award of a Practice Certificate by the Law Society. Our simulations on this course have been developed in the practice areas of Personal Injury, Conveyancing (the sale and purchase of property or real estate), Private Client (procedures relating to wills, estates, trusts, etc), Civil Court actions, and Practice Management.

The simulations themselves as well as the success of their social constructivist approach to learning and assessment have been described in some detail elsewhere (Maharg, 2004; 2006; 2007a, 2007b, Barton & Maharg, 2006; Barton, McKellar & Maharg, 2007). In brief, we created a fictional town on the web, Ardcalloch, the cultural and topographical lineaments of which were modeled on a typical Scottish west coast provincial town. Within the town, represented on the web by a map and a directory of businesses, institutions and citizens (see figures 1 & 2 below), we located the virtual law firms.

Within each firm are four students who, under the supervision of tutor-practitioners and a practice manager, carry out the legal work of the firm. The gradual development of the environment is described in Maharg (2007a). While it was the

Figure 1. Map of Ardcalloch

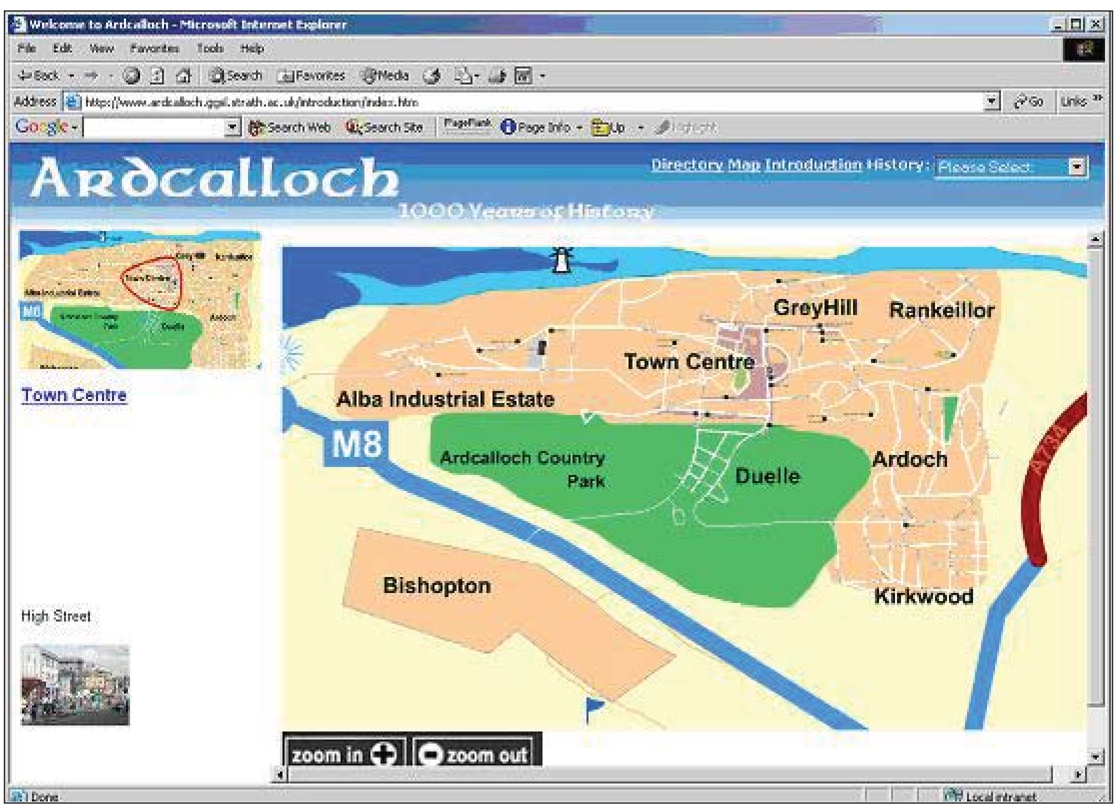


Figure 2. Ardcalloch directory

subject of internal working papers, the process by which the simulations were assembled has not been described until now. The procedures we developed were highly interdisciplinary, and involved legal practitioners, the use of educational theory and the application of this to the domains of computer science and sub-domains of human-computer interaction (HCI) and software engineering in particular. The three nodes of legal practice, education and computer science can be viewed as the three points of a triangle within which we constantly moved.

The process began when the educationalist and the legal practitioner drafted the educational aims of the simulation. The aims were embodied by the shape and content of the simulation itself; but the aims were also affected by the technology that we were using. For example, communication with a client needed to be specified quite early on in the design of the simulation: was it possible to have a client in the simulation that could be contactable by players? How might this be achieved? These and other issues were addressed in a framework that could best be described as a rudimentary form of the ADDIE model.

ADDIE however was too high-level for the problems we found ourselves faced with. If the process began in educational aims and moved quickly to legal practice and technology, it was never the case that we could design one element in isolation. Put simply, a problem in educational design inevitably involved the re-design of a practice component, which in turn could affect the design and use of technological components. We found ourselves drawn to the design not of simulation templates but by necessity the design of unique templates, each of which represented unique forms of legal transaction. Quinn's (2005) Design Spiral describes well the iterative process we found ourselves adopting, but within the iterations, we would be constantly moving among the three corners of the education-law-technology triangle (115). The process was time-consuming, highly iterative, and involved many meetings to discuss many aspects of interdisciplinary design and implementation. After the first implementation, the simulation would be extensively revised in the light of user feedback, fine-tuned, and the process would begin again.

After implementation of the first few simulations, we began to be aware of the subtle design issues that affected the success or failure of our professional simulations, including the following:

Authenticity

Clearly, simulations cannot replicate reality; nor does one need such immersion in a parallel reality. What is required is first, the *sense* of real context, which we describe in terms of depth of field, drawing from the work of Roland Barthes on photography (Barton & Maharg, 2006, pp.139-41). Which objects should be in the foreground of the learner's field, which should be backgrounded? Second, we came to realize that authenticity is a quality that derives not from mimesis of reality, but from identification of key forms of thinking, planning and ethical behavior that drive specific communities of practice (Barton & Maharg, 2006, pp.142-3).

Game Play Design

Games, of course, are quite different entities from simulations, though there can be many overlaps between implementations. The types of learning interactions defined above are simulation more than game. But if, as Adams suggests (2004), game play is composed of a perspective view, an interaction model, and the game play itself, how might this be defined in simulations of legal practice? In many respects, Adams' criteria mirrors educational research into effective learning from simulation and other constructivist environments. The perspective view is analogous to the sense that students need to gain of the holism – the entire sweep of a transaction – before they can fully appreciate the integration of its parts. This requires students to act upon the world of the transaction (interaction model) to gain a sense of the integrative whole, and the dovetailing of the detail. Finally, students need to focus on decision-making processes (drafting writs, letters, fact-finding, deciding on procedural routes in a court action for instance) in order to implement the interactive model.

Over several years the process became streamlined, but not necessarily because our design tools became more sophisticated (though there was improvement), but because the people involved in the process grew more expert with the concepts (such as the two outlined briefly above) and the process. Building each simulation was still a unique process involving complex iterative processes, both transactional design and technical processes. The iterations helped develop our understanding of the complexity of the processes involved in simulation (Miyake 1997); but our procedures grew to be person-specific, tied to particular members of staff who developed expertise in the procedures. This had obvious advantages in streamlining process, but major disadvantages too, in that knowledge was sunk into specific persons, rather than being distributed among the team. Many academics simply do not possess either the technical skills or have access to technical staff required to create simulations of complex cases. The development of simulations from scratch requires high levels of educational and technical skills. It was almost impossible to export this knowledge beyond the team at GGSL, which had serious implications for anyone else wishing to implement our simulation approach in professional education or work with us on interdisciplinary or inter-institutional simulations. A number of attempts were made, within the UK and internationally. None of them were particularly successful, largely because the levels of planning, support and integration demanded by the custom-made simulations were too high.

We began to realize to that the role of technical staff, working with academics and practitioners, became, in many respects, that of translator. They needed first to interpret what the academic required into technical language. This was not an insignificant feat. The characteristics that an academic considers when constructing and describing a case are not the same characteristics that a software programmer would need. The left-hand and right-hand columns in Table 1 below contrast the perspectives and issues between the different domains.

Between the academic and technical domains lie the activities of the instructional designer or systems analyst. The skills of such professionals differ from that of a traditional software developer as they play an interpreter's role, translating the academic requirements into coding specification. This set of translation skills, we found, is key to the production of effective teaching simulations. On one level, of course, these skills are critical elements in the professionalism of instructional designers. But not every university faculty can afford in-house designers in sufficient numbers to aid academic staff in their development of simulations Given this, and given the experience of academics working with designers, we hypothesized that it may be possible to design tools that would enable staff to translate their simulation ideas into simulation learning environments. Our approach was based upon a version of participatory design (Suchman & Trigg, 1991; Kensing & Munk-Madsen; Fowles, 2000), where two or more cultures can come together to create a third space, one which belongs to neither original culture, but which is formed from the interaction between the two. Grenfell's (1998) and Evanoff's (2000 – both cited in Muller below) studies of hybridity

Table 1. Perspectives on case study simulations

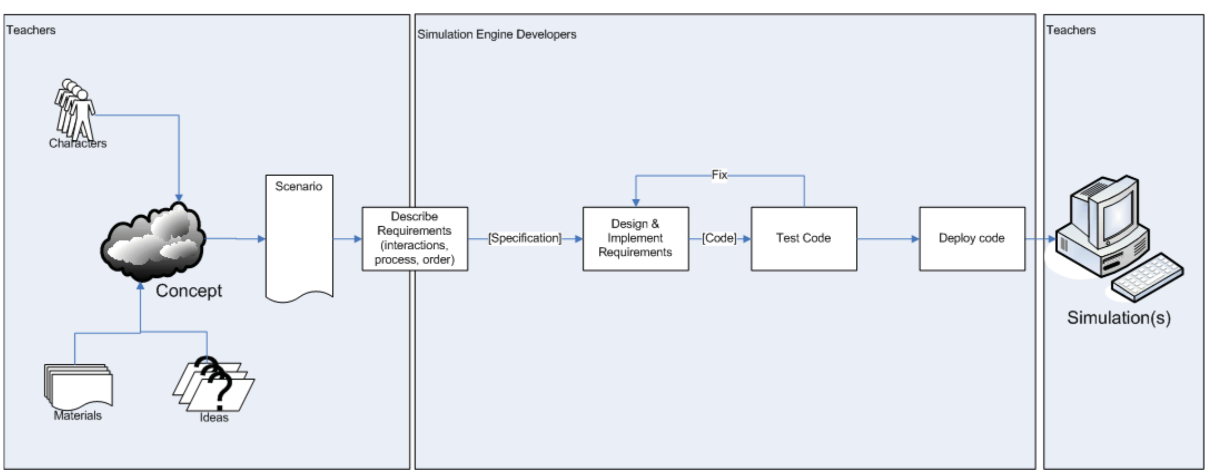
Academic Domain	**Instructional Designer / Systems Analyst**	**Technical Domain**
Scenario: • Narrative • Characters / stakeholders • Problem/plot • Organizational context • Player role • Timing • Activities for students • Activities for staff • Student deliverables Course: • Knowledge objectives for activity • Skills objectives for activity • Assessment methods (assignments, criteria, feedback) • Course learning outcomes • Complementary course activities • Resource constraints (timing, staff levels, class size, tutor skills, resources available for students to use) • Groups or individual activity • Student skills and prior experience • Peer contribution monitoring	Scenario Information: • Relationships between characters • Timings • Sequence • boundaries • Student deliverables • Information flow (actions) • Activity of users (players and staff) • Consumables (Problem/plot information, Character data) • States of consumables • Variability Resource constraints such as access rights. Groups or individual players Other systems and their interactions (e.g. assessment and feedback systems, peer contribution)	Interface Tools for user System information: • Meta roles of characters • Relationships between roles (and related users) • Information flows • Sequence • variables User lists

are good examples of research in this area, as is Muller's exploration of the ways in which hybridity enhances participatory design. He outlines eight key areas where participatory design can be enhanced by methods that enhance hybridity – 'selection of sites of shared work, workshops, stories, end-user photography, dramas, creation of shared languages, descriptive artifacts (low-tech prototypes), and working prototypes'. It is significant that at least four of these (sites of shared work, workshops, stories, descriptive artifacts) influenced our own design in the SIMPLE project (Muller, 2002).

Another significant example of a third space is Peter Galison's groundbreaking study of the material culture of modern experimental microphysics. Galison shows how the contemporary need for coordination between large research teams of scientists, engineers, computer programmers and many others creates a dynamic 'trading zone' in which theorists, writers, experimenters, instrument designers, policy-makers, politicians, architects and others meet, share knowledge and do collaborative research (Galison, 1997). Parties traded content and method; they imposed constraints on each other; traditions coordinated but without homogenizing; they communicated in pidgins and creoles to express and absorb each other's essential concepts. The trade is never neutral – as Galison points out 'nothing in the notion of trade presupposes some universal notion of a neutral currency' (1997, p. 803). The trade also expressed itself in distributed objects and schemas, understandable to the parties involved (Maharg, 2007a).

We therefore aimed to create an entirely new version of the software we used to create simulations and in the process to re-engineer our developmental processes. With the aid of funding granted by the Joint Information Systems Committee (JISC) and UK Centre for Legal Education (UKCLE), we completely rewrote the simulation software we had used hitherto. It was now an open-source application consisting of toolset and platform, and which would, at the conclusion of the project, be available to all Higher Education and Further Education in the UK free of charge at point of use. In the process, we also redesigned the process of simulation design and building that we had used for the past six years. Our aim was to create simulation tools that, with some training, could be used by academic staff to design simulation scenarios for their students. These scenarios would then be uploaded to a platform, and run as simulations in which students would perform roles and enact professional transactions.

Figure 3. Traditional development of Ardcalloch simulations



THE SIMPLE TOOL

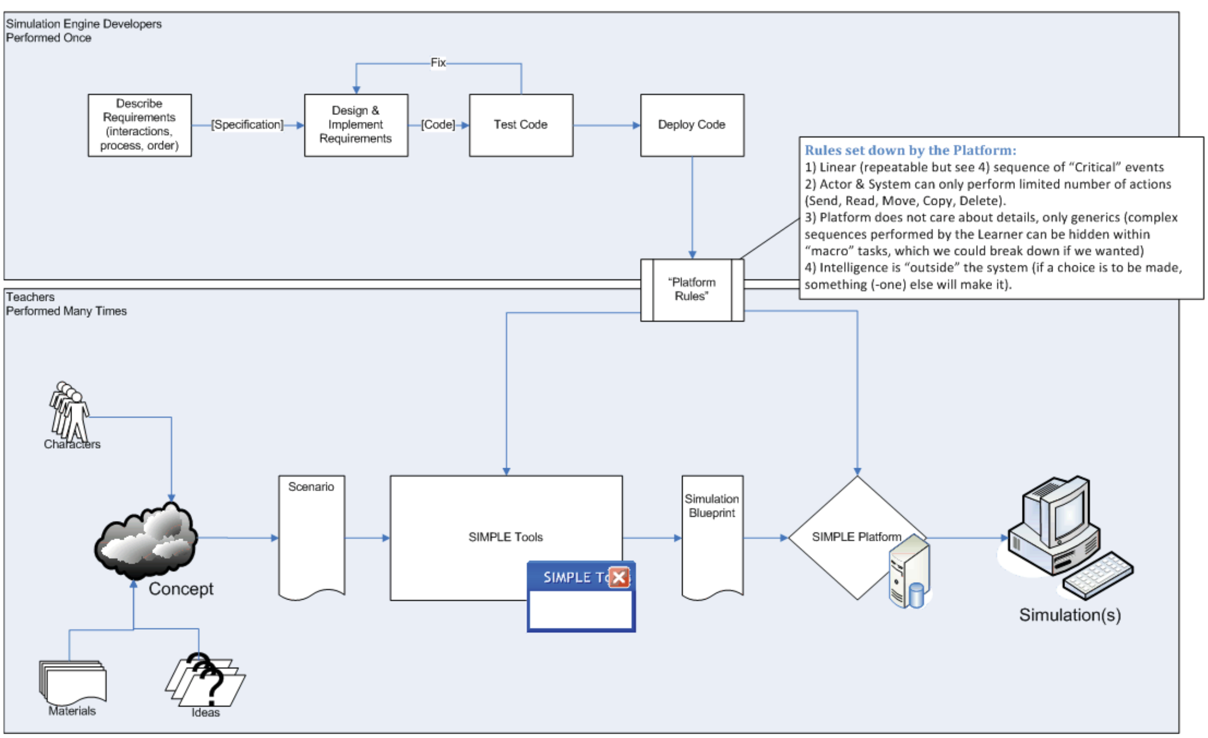
Traditionally, the technical staff of the Learning Technology unit fulfilled the translator role for Ardcalloch. While effective and enabling for the academic staff, this is a costly resource that would be unavailable to future users of the open source SIMPLE software. This approach is summarized in Figure 3 below.

However if the translation situation was costly and cumbersome, the educational design of the simulation as a transactional learning environment, had already been established through the development of Ardcalloch, and was well developed. Use of transactional principles (Maharg, 2007a) enabled us to produce a tool to replace the traditional role of the instructional designer, allowing academics to interact with the system that ultimately runs their simulations. The development of the Narrative Event Diagram (NED) provided both a participatory artifact and a language for academics to describe their scenarios graphically, and allowed the NED tools to translate scenarios for deployment through the SIMPLE platform. Figure 4 below illustrates the design process that created the tools.

THE NARRATIVE EVENT DIAGRAM (NED)

In developing a simulation for use in teaching the developer faces several challenges, not the least of which is the language barrier that exists between the technical expert and the academic for whom the simulation is being developed. At the start of the SIMPLE project, we began with the Unified Modeling Language (UML) of the existing PI transaction to model each subsequent simulation. UML is an object-oriented approach to modeling complex systems. However, it does not quite model the simulations that were run in the Glasgow Graduate School of Law (GGSL). There are many parties involved in building a

Figure 4. SIMPLE tool development process



coherent model, and in the case of a simulation such as the Personal Injury transaction, the UML becomes particularly complex due to the two sides negotiating the transaction at play within the system. Trying to model the parameters of both sides is tricky as both often simultaneously share resources and furthermore the resultant model requires sufficient expertise in systems analysis if it is to be interpreted accurately.

What happens if we apply a simpler method to guide the development of our simulation? That is, what if we discard the UML approach and use a medium or language that is more accessible to the academic? One possibility might be to perform the requirements-capture stage via a grammatical analysis of text such as Gee's analysis (1996). This might work up to a point but requires too much discretion to work well and has the obvious limitations inherent with relying on text, such as variation in discourse markers, differences in writing style, readers' interpretation and the brevity of many descriptions. Alternatively, using block diagrams offers good graphical resonance with most audiences and allows a problem to be represented by both a structured writing approach and via the use of an easy-to-follow box format. However while useful for systems analysis a block diagram is heavily oriented towards a 'black box' view of knowledge and understanding, as well as being (in our experience) difficult to adapt to a description of simulation process. It could not contribute to the development of participatory design, nor would its opacity help create a trading zone among the participating authors.

After consideration of both block diagrams and flow charts, we adopted a version the latter for their ability to represent decision choices, which are critical events in student learning and often in assessment practice. They are also an easily understandable way of representing information flow within a system. Flow charts can represent both sides of the Personal Injury and Private Client transactions, which cover the range of open-field and bounded-field simulations deployed in the GGSL (Barton & Maharg, 2007, 119). However, as development proceeded and as more players and options were added, these flow charts grew increasingly as complex and unwieldy as anything produced via more formalized systems analysis methods. Any benefits of using this approach, such ease of use, were cancelled out by a loss of clarity and a lack of visible process. We needed to find or develop a tool that made representation clearer but which retained language constructs.

We then considered the Instructional Management Systems IMS Global Learning Consortium's Learning Design (IMS LD – see http://www.imsglobal.org/) as a possible means of achieving our goal. In IMS LD, the persons interacting do so in role, carrying out a specified action in a specified environment. Learners of course always bring their own intention and motivation to learning activities, which may give rise to unplanned outcomes, or may interfere with the achievement of the planned outcome. It is almost impossible to represent these intentions, and the often highly complex and ever-changing situations in which they manifest themselves. Whether or not intentions give rise to undesirable outcomes, uncertainty about role is rarely productive within a simulation. To help to define roles in an LD workflow, therefore, the learning and teaching scenario is described using the metaphor of a theatrical play. Accordingly, the scenario is divided into Acts with each Act containing one or more Role-Parts. Each Role-Part associates one Role with one Activity or Activity-Structure. Acts are sequential, which leads to a sequential workflow (Britain, 2004). IMS LD provides an XML framework for describing any form of interaction using this metaphor as well as a process for applying a vocabulary to describe a sequence of interactions in an interactive program. However, any development meant working with XML directly; no specific tools were provided beyond this schema. At the specific point in time that we were developing the SIMPLE project, therefore, working with IMS LD in this way would have been an extremely cumbersome and time-consuming process. Britain acknowledged that:

[e]ven if teachers were used to developing scenarios in narrative form very few would contemplate turning these into UML diagrams and then IMS-LD conformant XML. Software tools are needed that will support the authoring of learning designs and tools are needed to play learning designs in a run-time environment. (Britain, 2004)

To summarize, therefore: each of these approaches had significant advantages, which were counter-balanced by their disadvantages. To address our specific requirements in SIMPLE, we synthesized a tool that would combine:

- The conceptual immediacy of a graphical approach
- The processes found in structured systems analysis

By combining these key attributes, we wanted to design a tool that was sufficiently structured to meet the technical demands required to automate the design of a simulation, and at the same time design a tool that would be accessible to a non-technical audience.

Our tool, the Narrative Event Diagram (NED, figure 5 below), allows an author to describe the scenario in a high-level language (read document, correspond with X, negotiate with Y, etc) in comparison to the atomic actions that the underlying simulation engine uses (Read, Write, Send, Move, Copy, Delete) in order to manage the scenario. All of the actions that the learner will perform are typically compound, complex actions that are repetitions of the atomic actions.

The NED uses a highly graphical approach to describe scenarios (see figure 3). This allows important information to be presented in a more immediate and accessible form. It is also ideally suited to a wide range of practical design approaches: it is interesting to note that the first scenarios designed using the NED were hand-drawn rather than designed using the computer.

When building a simulation the author's identifies the narrative events and tasks that form the broad outline of the simulation. Using the NED we are able to classify major incidents that generate scenario information or affect the scenario's parameters (for example a car accident taking place) as Events. These events are placed onto the Critical Events line in the diagram, and by following this line it is easy to form a general picture of what happens in the scenario. The specific details of the scenario can then be implemented within the tasks and resources given to the learner.

Tasks, as their name suggests, are things that must be done by a particular character within a scenario and can range from simple tasks (e.g. drafting a clause in a formal legal document) through to complex, compound tasks (e.g. negotiate settlement with opposing lawyers). If Events represent what happens in a scenario, Tasks represent the reactions to events or another element of the scenario. An author must decide whether a particular task is being performed by the player or a simulated character. If the task is not performed by the player (learner), the task is classified as a Non-Player Character (NPC) task and is placed on the NPC Activity line; otherwise it is placed on the Character line (Salen and Zimmerman, 2004, 2006; Bartle, 2004). As the author fleshes out the simulation with reactions to events, the tool represents visually the relationships and the flow of information.

By placing a task on the NPC Activity line, the author is required to provide additional information such as which Non-Player Character is actually performing the task (or it may be multiple characters). Authors have most control over the items on the NPC and Critical Event lines; they have very little control over the items on the Player line, as the intentionality of Player/learner is outside of their direct control, as we indicated above. Figure 5, below, is a representation of the final NED for one of our simulations, namely the Personal Injury Negotiation Project.

From the point of view of the player/learner, the NED shows the interactions between a specific performer and everyone else. The consequence of this is that as events and tasks are dropped onto the diagram and allocated to performers the diagram begins to take on a form that is very similar to the appearance of musical notation. Individual tasks become individual nodes. The exception to this is where a task subsumes another task that is performed outside of the simulation; in which situations a musical chord pattern appears. In multi-party scenarios (where there are two or more player-characters), synchronous tasks and events do occur, but by limiting the scope of an NED to a single player-character viewpoint, the complications caused by multi-party scenarios are effectively reduced.

All of this, of course, was the subject of constant design iteration within the SIMPLE project. As an example of this, Figure 6 below shows an early attempt to display the two player-character narrative diagrams within a single transaction at the same time, and shows where NPC tasks in one NED are Player tasks in the other. It is interesting to compare it to Figure 5. The project tasks and characters remain largely the same in each. However the addition of the horizontal 'stave' lines gives structure and clarity to roles and tasks that would otherwise remain more obscure and certainly more difficult to define within the simulation.

It is important to control the pacing or rate of play for a simulation. This has two aspects: first, an underlying process or transaction which has its own period (the time required to complete the whole process as well as the pace of tasks), and second, the pacing of events and tasks to coincide with real world teaching. Given the clear similarities between the diagram and musical notation, to avoid introducing any other conflicting metaphors, we decided to adopt musical bar-lines to give a visual indication of pace. Each bar-line represents the end of a single period, and the physical space between bar-lines is irrelevant: it is possible to have one event between the bar-lines, or 30 – the time period would remain the same. This addresses the first aspect of pacing (the simulation's internal time), but it also addresses the second

Figure 5. Final personal injury project NED (Pursuer)

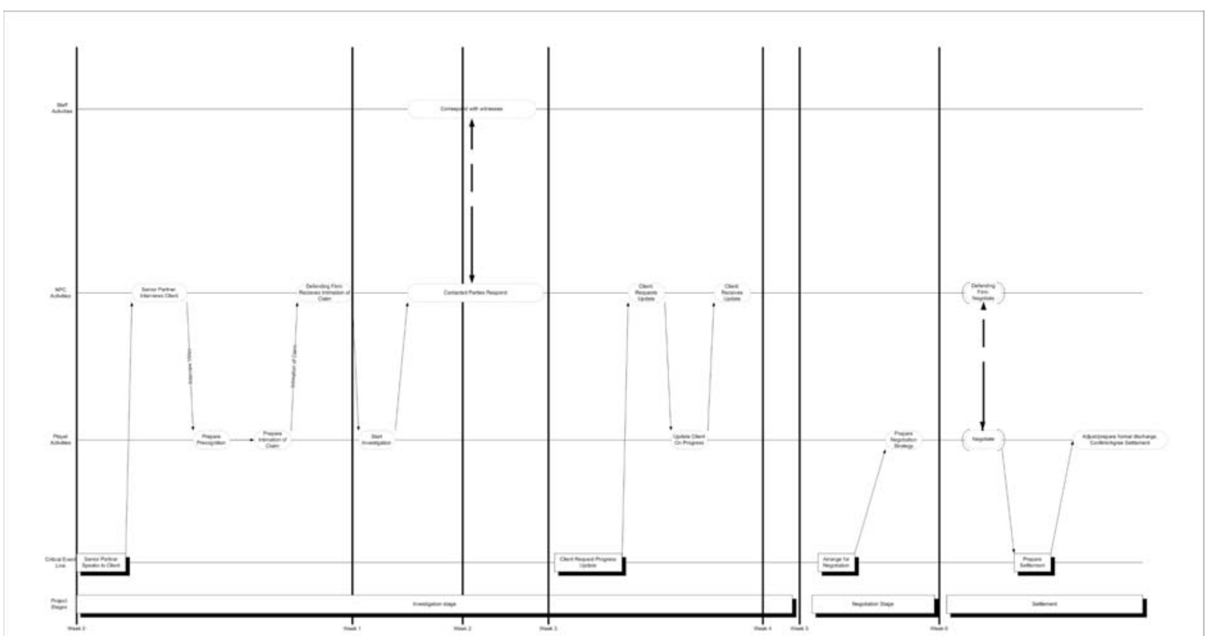
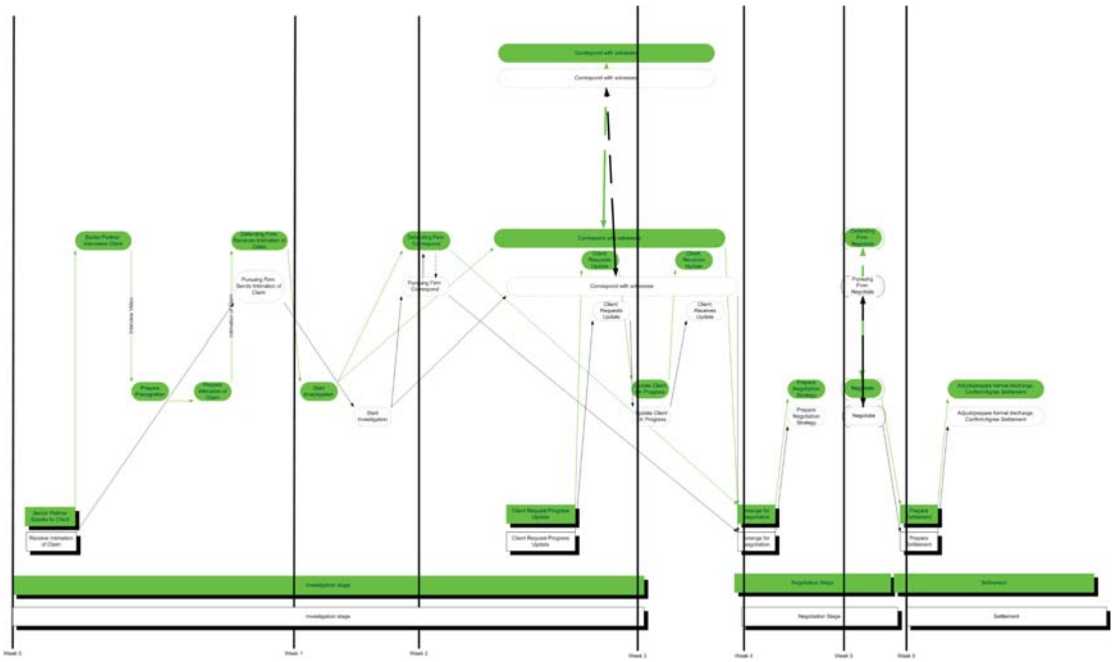


Figure 6. Personal injury project (Pursuer & Defender) NED



aspect: each bar-line can serve as a gatekeeper or filter (to adopt a term from communicational studies—White, 1950), where the learner can be paused until an appropriate class has been taught (Lewin, 1947; Feldman et al, 1994).

Using these elements, it should be possible to describe almost any form of activity based on the passing of information between two or more parties. A graphical approach to building simulation models in this way allows authors to see the structure clearly. Over time and as authorial experience increases, incorrect interactions can be clearly seen as unexpected patterns, without having to engage in in-depth reading to get to the meaning. This familiarity is typical of the process of reading music, to the point where experienced sight-readers read sets of notes, not individual notes, and where the qualities of anticipation (of what is about to appear) and memory (what has been performed) are crucial. It is interesting to note that this familiarity is not found in alternative metaphors, for example the play metaphor (i.e. representation of a play as a script) that is applied in IMS LD.

The metaphor has other advantages. The significant aspects of the underlying model (sequence, pace and interaction) are exposed very early in the process of development (for the music metaphor is essentially a chronological timeline), and in a manner that is clear and unambiguous. In addition, and if we refer back to Adams' definition of game play as being composed of perspective view, interaction model and the game play itself, it is interesting to note that learning the sequence is equivalent to gaining a perspective view of a transaction; pacing focuses on one of the critical qualities of interaction models that is sometimes ignored in simulation design; while interaction defines much of the game play within the simulation.

The NED tool allows the author to start from a very vague series of events, and iteratively to add more detail to the model in a mechanism that is not only easily transferable (in that it is not entirely reliant upon language skills for interpretation) but is also easily transformable from the high-level description to the low-level code required by the SIMPLE platform to run.

The Narrative Event Diagram is a highly transferable process, as opposed to a format. It is not tied to any particular technological implementation: an NED. can be created using pen & paper. The SIMPLE Tools are a particular implementation of the NED approach, which utilizes an XML format to persist the diagram. Providing appropriate mappings can be established between a N.E.D. element and a persistence object, it would be possible to utilize the NED approach with an alternative storage mechanism such as IMS LD.

In summary, the NEDs were developed through an iterative dialogue between academics, working with the elements described in the academic domain of Table 1, and SIMPLE technical developers with their experience of the Ardcalloch-based simulations. Its construction elicits the key elements of the simulation in a structured manner that follows the principles of transactional learning. It takes academics from the case scenario description at the level of a five-minute 'film pitch', focused on the crucial narrative aspect of the case, and requires them to break this down into player activities, character activities and information flows. The visual nature of this representation, based upon analogies with a music stave, enables academics with little or no technical skills to see the structure and flow of the scenario.

STAFF RESPONSES

Given our ambitious aims to replace the face-to-face ecology of the pre-SIMPLE environment with a set of on-screen tools, how did staff respond, and what have we learned from it? We are still in the process of collecting data, but it is already clear that there is a spectrum of responses to the NED and other tools. At one extreme, staff in two different disciplines (Architecture and Management Science) found the tools intuitive and were able to use them to construct simulations of variable complexities. At another extreme, some staff were baffled – indeed appeared to be intimidated by the concept of the tools, even before they engaged with them as on-screen utilities. This appears in part to be linked to attitudes towards IT generally (something we comment on more generally below). For instance, Management Science and Architecture are more familiar than others with the concept of flow-charting and project management via graphical tools. There seemed to be an expectation that they would not be able to understand the tool, regardless of the support literature and help they were given.

Experienced simulation designers at GGSL were not free from problems in using the NED approach. The approach fundamentally altered the way they had previously thought of simulations primarily as transactions linked to context and resources made available to learners, rather than as a linear, narrative structure of events and tasks. However, NED elements were easily mapped on to their existing vocabularies, and integrated with them. What was more difficult to absorb was the NED process itself. Across the range of experiences some simulation authors found the process easy to comprehend while others struggled with the interface. We shall address many of these issues in the next developmental cycle.

More serious for widespread adoption of the application will be the underlying attitudes of staff towards constructivist learning and simulation generally. Maharg (2006) has commented on the reasons why this might be so, in his analysis of the research on staff uptake of ICT. Coupal (2004) for instance, identified three stages of development in ICT use by teachers: 'literacy uses (a technology-centered pedagogy); adaptive uses (a teacher-centered, direct instruction pedagogy); and transforming uses (a student-centered, constructivist pedagogy)', and pointed out how problematic it was to achieve the third stage (59), as noted by other researchers (Bottino, 2004). Researchers have also pointed out how affect and the use of such sophisticated ICT tools are closely related to how teachers perceive the effects of ICT on their practice. Over a decade ago Klem and Moran (1994) analyzed why teachers had negative reactions to ICT. In their study, teachers viewed ICT as bringing about a loss of power, control and authority within the traditional teaching environment. Their view of technology was that, to misquote Christensen, all technology was disruptive; very little of it was seen as being sustaining of traditional educational practices.

Penteado (2001) came to the same conclusion as Klem and Moran, but she postulated that such confrontation between old and new was inevitable, a result of teachers using technology and being forced to move from what she called relative comfort zones into risk zones. As a consequence, and at a deep level, teachers are required to re-negotiate their educational practice in order to use technology. Such re-negotiation is dependent on many factors, including feelings of certainty about course content, experience of teaching the course, experience with some of the technology being used or none of it, the perceived riskiness of the technology in use with students, support offered by management in the use of ICT.

No program of this nature is ever going to be as easy to use as creating a blog posting: the sophistication of the simulation structure and content require sophisticated tools. We need to better support academics with more sophisticated support materials, and set expectations before people even see the tools. In this respect there is a lot to be learned from the online support materials and tools developed in sophisticated MMORPGs such as World of Warcraft, and which are analyzed in depth in, for instance, the work of James Gee (2003 – see also Dickey, 2007). These will be essential for the arrival of 'second-wave' developers after the formal end of our project in July 2008. These staff will not have the support that first-wave staff have had during the SIMPLE project; but on the other hand the SIMPLE educational and development core team are now better able to write tools for them, having had the experience of creating the first iteration of the application. In addition, a key element of support will be the authors themselves for whom we are creating the conditions under which a community of practice in simulation design we hope will arise. The community's resources will include not just technical literature, but models of simulations that are already running, the blueprints of scenarios, and descriptions of how pedagogical models such as transactional learning (Maharg, 2007a) are implemented.

REFERENCES

Adams, E. (2004). *Designing with gameplay modes and flowboards.* San Francisco: Gamasutra, http://www.gamasutra.com/features/20040510/adams_01.shtml.

Aldrich, C. (2005) *Learning by Doing: A Comprehensive Guide to Simulations, Computer Games, and Pedagogy in e-Learning and Other Educational ExperiencesSan Francisco*, Pfeiffer.

Ball, P.,Thornbury, H. (2004). A Student Learning Environment without the Overhead? Reviewing Costs and Benefits of CAL within a Manufacturing Course. *International Journal of Engineering Education, 20*(5), 713-725

Bartle, R. A. (2004). *Designing Virtual Worlds.* New Riders, Berkeley, CA

Barton, K., & Maharg, P. (2006). Simulations in the wild: Interdisciplinary research, design and implementation. In C. Aldrich, D. Gibson, M. Prensky (Eds), *Games and simulations in online learning* (pp. 115-148). Hershey PA: Information Science Publishing.

Barton, K., McKellar, P., & Maharg, P. (2007). Authentic fictions: Simulation, professionalism and legal learning. *Clinical Law Review*, 14(1), 143-93.

Blackburn, T. (2003). *Simulator-based learning for obstetric anaesthesia.* Paper presented at the ASME Conference. Available at http://www.uni-mainz.de/FB/Medizin/Anaesthesie/ SESAM/Downloads/Abstracts%202003.pdf. Accessed 27/02/07.

Bloxham, S. M., & Armitage, S. (2003). What a LUVLE way to learn law. *International Review of Law Computers and Technology, 17*, 1, 39–50.

Bottino, R .M. (2004). The evolution of ICT-based learning environments: which perspectives for the school of the future? *British Journal of Educational Technology*, *35*, 5, 553-567

Britain, S. (2004) *A Review of Learning Design: Concept, Specifications and Tools. A Report for the JISC E-learning Pedagogy Programme*, at http://www.jisc.ac.uk/media/documents/programmes/elearningpedagogy/learningdesigntoolsfinalreport.pdf, last accessed 20.3.08

Callon, M., & Latour, B. (1981) Unscrewing the big leviathons: how do actors macrostructure reality, In K. Knorr, & A. Cicourel, (eds.), *Advances in Social Theory and Methodology: Toward an Integration of Micro and Macro Sociologies*. London: Routledge, (pp. 277-303).

Christensen, C. R. (1987). Teaching with cases at Harvard Business School. In C. R. Christensen (Ed.), *Teaching and the Case Method: Text, Cases and Readings.* Boston: Harvard Business School. (pp. 16-49).

Coupal, L. V. (2004). Constructivist learning theory and human capital theory: shifting political and educational frameworks for teachers' ICT professional development. *British Journal of Educational Technology*, *35*(5), 587-596.

DeLacey, B. J., & Leonard, D. A. (2002) Case study on technology and distance in education at the Harvard Business School. *Educational Technology and Society, 5*(2), 13-28.

Dickey, M. D. (2005) Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. *Educational Technology and Development*, *53*(2), 67-83.

Dickey, M. D. (2007). Game design and learning: A conjectural analysis of how massively multiple online role-playing games (*MMORPGs) foster intrinsic motivation. Educational Technology Research and Development, 55*(3), 253-273.

Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology* (pp. 170-198). New York: Simon Schuster Macmillan.

Evanoff, R. (2000). The concept of "third cultures" in intercultural ethics. *Eubios Journal of Asian and International Bioethics, 10*, 126-129.

Feldman, D. H. Csikszentmihalyi, M., & Gardner, H. (eds.) (1994). *Changing the World, A Framework for the Study of Creativity.* Praeger, Westport.

Forrest, F. C., Taylor, M. A., Postlethwaite, K., & Aspinall, R. (2002). Use of a high-fidelity simulator to develop testing of the technical performance of novice anaesthetists. *British Journal of Anaesthesiology*, *88*(3), 338–44.

Forrest, F. C., Grimes, S., & Postlethwaite, K. (2003). *Does debriefing novice anaesthetists after simulator practice improve technical performance in the first three months of training*? Paper presented at the ASME 2003 Conference. Available at http://tinyurl.com/2o5cuy. Accessed 27/02/07.

Fowles, R. A. (2000). Symmetry in design participation in the built environment: Experiences and insights from education and practice.

In *Proceedings of CoDesigning 2000*. London: Springer.

Galison, P. (1997). *Image and Logic: A Material Culture of Microphysics* (Chicago, IL, University of Chicago Press).

Gee, J. P. (1996). Social Linguistics and Literacies. *Ideologies in Discourses*. New York, RoutledgeFalmer.

Gee, J. P. (2003). *What Video Games Have to Teach Us about Learning and Literacy.* New York, Palgrave Macmillan.

Gredler, M. E. (1996). Games and simulations and their relationships to learning. In D.H. Jonassen (ed.), *Handbook of Research on Educational Communications and Technology*, 2nd ed. Mahwah, NJ, Lawrence Erlbaum.

Grenfell, M. (1998). Border-crossing: Cultural hybridity and the rural and small schools practicum. Australian Association for Research in Education Conference.

Kensing, F., & Munk-Madsen, A. (1993) PD: Structure in the toolbox. *Communications of the ACM 36*(6), 78-85.

Kilpatrick, W. H. (1918). The project method. *Teachers College Record, 19*, 319–355.

Lewin, K. (1947). Frontiers in group dynamics II: Channels of group life; social planning and action research. *Human Relations, 1*, 143-153.

Li, E. Y., & Baihlie, A. S. (1993) Mixing case method with business games: student evaluations, *Simulation & Gaming*, *24*, 3, 336-355.

Maharg, P. (2004). Virtual communities on the web: Transactional learning and teaching. In A. Vedder (Ed), *Aan het werk met ICT in het academisch onderwijs* (pp. 75-93). Nijmegen: Wolf Legal Publishers.

Maharg, P. (2006). On the edge: ICT and the transformation of professional legal learning. *Web Journal of Current Legal Issues*, 3, http://webjcli.ncl.ac.uk/2006/issue3/maharg3.html.

Maharg, P. (2007a). *Transforming Legal Education: Learning and Teaching the Law in the Early Twenty-First Century*. London: Ashgate Publishing.

Maharg, P., & Owen, M. (2007b). Simulations, learning and the metaverse: Changing cultures in legal education. *Journal of Information, Law, Technology, 1.* http://www2.warwick.ac.uk/fac/soc/law/elj/jilt/2007_1/maharg_owen

Miyake, N. (1997) Constructive interaction and the iterative process of understanding, *Cognitive Science, 10*(2), 151-77.

Muller, M. J. (2002). Participatory design: the third space in HCI. In J.A. Jacko, A. Sears (eds), The *human-computer interaction handbook: fundamentals, evolving technologies and emerging applications*. Lawrence Erlbaum, Mahwah, NJ, (pp. 1051-68).

Penteado, M. (2001). Computer-based Learning environments: risks and uncertainties for teachers. *Ways of Knowing Journal*, *1*(2), 22-33.

Quinn, C. N. (2005). Engaging learning. *Designing e-learning simulation games*. San Francisco: Pfeiffer.

Salen, K., & Zimmerman, E. (2004). Rules of Play. *Game Design Fundamentals*, Cambridge, MA, MIT Press.

Salen, K., & Zimmerman, E. (2006). *The Game Design Reader. A Rules of Play Anthology*. Cambridge, MA: MIT Press.

Stenhouse, L. (1983) *Authority, Education and Emancipation*. London: Heinemann Educational Books.

Suchman, L., & Trigg, R. (1991) Understanding practice: video as a medium for reflection and design. In J. Greenbaum & M. Kyng (eds.), *Design at Work: Cooperative Design of Computer*

Systems. Hillsdale NJ: Erlbaum.

White, D. M. (1950). The "gate-keeper": a case study in the selection of news. *Journal of Quarterly, 27*, 383-390.

Wolfe, J., Guth, (1975). The case approach versus gaming in the teaching of business policy: an experimental evaluation. *Journal of Business, 48*, 3, 349-64.

Wolff, S. J. (2002). *Design Features of Project-based Learning.* Minneapolis, MN: DesignShare. www.designshare.com