

The Educational Value of Microworld Simulation

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Abstract

Microworlds as computer-based simulations can be important tools to support learning. In this respect, microworld simulation has been said to build substantial synergy between learning to think in systems frameworks and learning to deal with the complexity of actual settings. Since the first microworlds were introduced, their educational value has been accepted as an article of faith. In this paper the implications and results of adopting microworlds are explored in terms of student learning, educational approach and course design. These implications are illustrated with quantitative and qualitative questionnaire data obtained from courses in undergraduate Business programs as well as a post-experience MBA-program. In general, these data suggest that learning processes can be deepened and accelerated by creating effective combinations of lectures, cases, readings and microworlds.

Key Words:

Business simulation, microworld, student learning, undergraduate courses, MBA-courses.

Introduction

Recent developments in the area of business simulation create opportunities to build substantial synergy between learning to think in relevant theoretical frameworks and learning how to deal with the complexity of actual settings. An increasing number of microworlds have been and are being developed at the Sloan School of Management (MIT), London Business School and other universities and schools. Since microworlds were first introduced in higher education, their educational value has been accepted as an article of faith. Thus, there is no research that evaluates the process and outcomes of learning in the context of microworld simulations (Maier and Grössler, 2000). This study evaluates the practical implications and learning outcomes of the adoption of microworlds as tools that may prepare undergraduate students for managerial work and deepen and accelerate learning by part-time MBA-students.

In this respect, the implementation of microworlds in several programs for business education will be explored. The educational implications and outcomes of using microworlds are explored as follows. First, the microworld concept is defined and distinguished from other simulation tools, and illustrated with two microworlds: the mobile phone and professional services microworld. Subsequently, the implications of adopting microworlds for student learning, teaching approach and course design are described. These implications are explored in courses in pre-experience as well as post-experience programs in which microworlds have been implemented.

Microworld as learning tool

Teaching and education in business and management is increasingly based on technological innovations in the area of multimedia and computer-based instruction (Alavi et al., 1997). One of these innovations is the so-called “microworld”. The concept of a microworld was first defined by Papert (1980). Gradually, it has come to mean any simulation in which people can participate by running experiments, testing different strategies, and building a better understanding of the aspects of the real world which the microworld depicts. Other words that have come into use are management flight simulators, business simulators and learning laboratories.

The idea of the microworld as a kind of flight simulator for managers and management students became well-known through Senge’s *The Fifth Discipline* (1990). Senge argued that human beings learn best through firsthand experience, or ‘learning by doing’. However, learning-by-doing only works so long as the feedback from one’s actions is rapid and unambiguous. This leads to the so-called dilemma of learning from experience: one learns best from experience, but this learning only occurs if the consequences of important decisions and actions are experienced in an unambiguous and rapid manner (Senge, 1990). In order to deliberately and effectively create opportunities for experiential learning by management students, microworlds compress time and space. Thus, it becomes possible to experiment and to learn when the consequences of decisions and actions are in the future or in distant parts of the organization.

Microworlds are simulation tools for supporting learning about a business system, based on an explicit model of that business system. For example, the well-known *People Express* microworld is based on a model of the airline business. As such, microworlds can be distinguished from modeling-oriented simulation tools, such as Vensim, Powersim and Ithink, which can help users to understand the principles of a certain system by actively participating in the modeling process themselves (Vennix, 1996; Rouwette *et al.*, 2001). The usefulness

and efficacy of both microworlds and modeling-oriented simulations are virtually undoubted within the system dynamics community, but have not been systematically investigated (Maier and Grössler, 2000; Rouwette *et al.*, 2001; Thompson, 1999).

This study focuses on microworlds and in particular on the usefulness of two microworlds: the *Mobile Phone Subscriber Microworld* and the *Professional Services Microworld*. A short overview of both microworlds is given in Appendix 1.

Educational objectives

The main objective for using microworlds as an educational tool is to motivate and facilitate students toward deeper and more integrated understanding. In this respect, a well-known distinction in the literature on student learning is between the surface and deep approach to learning (Reynolds, 1997; Martin, 1999; Freeman and Capper, 2000). The surface approach is tied to what is given in a specific learning situation, for example, a text, problem or assignment. The focus is on providing an answer in terms of the specific instance. Students adopting this approach are satisfied with memorising isolated facts, concepts or ideas (Freeman and Capper, 2000).

A deep approach to learning goes beyond the given situation or problem, and explores the larger issues represented by a particular problem (Martin, 1999). This approach arises from one (or a combination) of the following conceptions: learning as understanding, making sense or abstracting meaning; learning as interpreting and understanding something in a different way, that is, by reinterpreting knowledge; and finally, learning as changing as a person, that is, seeing one's own position in the world differently (Martin, 1999).

Microworlds are more likely to be productive and valuable in the context of deep learning than for surface learning. The complex interplay of variables and forces in microworld simulations may challenge students to make sense of a certain problem in its wider setting. Moreover, strategies that do not seem to work challenge students to explore changes in their mental maps and theories, particularly by raising and answering '*what if*' questions. The integrated systems perspective incorporated in microworlds may also lead students to rethink their own professional expectations, ambitions and career plans.

Educational implications

In order to achieve deep learning outcomes by adopting microworlds in a given course, several other conditions on the level of course design and teaching approach are required (cf. Ramsden, 1992). First, the emphasis should be on teaching and assessment methods that foster active and long-term engagement with learning tasks, rather than methods emphasizing recall or the application of trivial knowledge. Second, frequent feedback on (lack of) progress is probably an important condition for learning from work on a microworld.

In general, microworlds can be adopted and implemented as an add-on to the current, preferably deep, approach used by the teacher in question. If the previously existing approach focuses on case studies, the microworld can be introduced into the course as a case study supported by computer simulation. As such, the microworld creates opportunities to experience the dynamics of key strategic issues found in a real business case situation. If the existing approach is more based on lectures and readings, microworlds can be implemented in order to increase opportunities for experiential learning.

Depending on personal preferences and other conditions – such as class size and the availability of computer facilities – simulations on the microworld can be done under supervision in the classroom or without supervision on computers selected by the students. In the latter case, a more structured process of delivering reports and subsequent feedback in follow-up sessions will be necessary. Students can work alone on simulation assignments, but they can also work in teams when teamwork is considered to be important (in view of the objectives of the course or entire program). In general, microworlds appear to be quite flexible tools that can be easily incorporated in existing course designs.

Microworlds in undergraduate and postgraduate courses

The implications of adopting microworlds can be illustrated with data from three courses, two at the undergraduate level and the other in a post-experience MBA-program. First, the Mobile Phone microworld was used in Introduction to Business Studies, an introductory course in the first year of the undergraduate Business Studies program at Tilburg University. The main objective of this course is to build awareness and understanding of the dynamics, complexity and variety of the business world. The course exposes students to a large number of critical issues, such as different options for organizing business, managerial decision making, communication, marketing, operations management, finance and accounting, and business ethics. Furthermore, this course explores the changing environment of business and the implications for organizations and their management. By way of a combination of lectures, assignment work in teams (of 4 or 5 students) and individual self-study, a basic understanding of the interdependencies and interactions between decision-making, marketing, operations, and so forth, is developed.

The Mobile Phone microworld is used in the last two weeks of this course to create opportunities for experiencing these complex interdependencies. Students downloaded the software from one of the university's computer servers on local computers in the campus area, or via internet from a website specifically designed for this purpose on their own computers. On the basis of a user guide and two assignments, each team worked on the microworld in its own pace. Feedback was given in plenary sessions in which all students participated and by means of questions and answers processed by means of the digital learning environment created for this course.

Microworlds were also used in an elective course on *Management and Organization* in the third year of the undergraduate Business Economics program at Tilburg University. This course explores a number of recent issues in the area of services management, organizational learning, leadership and systems thinking. The course was largely based on readings, assignments, presentations by students, and short lectures by the teacher. Both the introductory Mobile Phone microworld and the more complex Professional Services microworld were adopted to illustrate systems thinking applied to (services) management. The Mobile Phone microworld was used early in the course, and the Professional Services microworld near the end. The simulation work was triggered by assignments outlined in the course manual: students were asked to work in small teams with the simulation software in order to create a certain outcome (e.g., 200 % growth in the number of subscriptions under certain financial restrictions, by at least two different scenarios) and make sense of their strategy, any unintended consequences and the outcomes.

In this course students downloaded the software from the university's computer server on local computers in the campus area, or picked up a cd-rom in order to install the software on their own computers. For both microworlds a user guide was available. This mode of delivery was chosen because it is very flexible, providing students the opportunity to use the software

in their own pace and to spent as much time on it as needed. Feedback was given in plenary sessions as well as by means of open office hours.

Finally, the *Strategic Management* course in an executive MBA-program provided a somewhat different educational context for using microworlds. This program emphasizes action learning by a combination of a limited amount of readings, cases, assignments regarding the participants' work settings, classroom discussion and feedback. About half of the participants in this program come from professional services firms, and the other half comes from industrial companies and not-for-profit organizations. In this course, the Professional Services microworld provided students with the opportunity to learn to see patterns in the complex interaction between tangible and intangible resources in professional service firms (cf. Box 1), and explore strategies for dealing with these patterns. The participants prepared for the session by reading an introductory article on strategic resources and system dynamics. The software was installed to a number of notebook computers prior to the full-day session. The session was held in a seminar room with one computer connected to a screen visible for all participants and sufficient notebook computers for both individual and group work. This mode of delivery was chosen in view of time constraints, both in terms of teaching time and preparation time of participants.

Learning through microworlds: some findings

The two courses described in the preceding section have been evaluated by program management on the basis of standard evaluation forms distributed among the participants at the end of the course.¹ The evaluation approach used by program management was different in all cases and therefore not comparable. Moreover, these evaluations did not assess the value of microworld simulation tools, which were completely new to these programs. Thus, a short evaluation form, involving thirteen closed and three open questions, was developed in order to explore the value and usefulness of microworld simulation.² In addition to several practical conditions (e.g. user guide, software), the feedback by the instructor and the nature of group dynamics in the respondent's team are addressed in this evaluation form. Feedback by the instructor as well as group dynamics can have a strong influence on learning and decision-making processes, and thus affect learning effectiveness (Maier and Grössler, 2000). With regard to group dynamics, three questions regarding the quality of team collaboration were taken from the Group Style Instrument developed by Watson et al. (1998).

This short evaluation form was handed out together with the standard evaluation form by program management at the end of each course. The junior undergraduate course was taken by 171 students (number of respondents = 162). The senior undergraduate course was given two times, and was taken by a total number of 69 students (respondents = 63). The MBA-course was given three times (with 54 participants and respondents). Table 1 gives an overview of the descriptive statistics regarding the closed questions used in the evaluation. This table provides only descriptive statistics and not correlations because the latter would suggest a false belief in simple cause-effect relationships (Forrester, 1961 and 1971; Sterman, 1989). The descriptive statistics in Table 1 are used here to explore the educational value of microworlds as perceived by student-users.³

The results show that prior experience with microworld simulation was completely absent in the undergraduate courses and very low in the post-experience course. Table 1 also reports the perceptions of participants regarding a number of conditions: the quality of the software and user guide; coherence and usefulness of the theoretical framework outlined in readings and lectures; quality of the assignments; and the usefulness of the feedback given by the lecturer. These conditions were evaluated positively by the participants in all courses. In general, these

conditions can together be viewed as a *conditio sine qua non* for effective use of microworlds. Marsick and O’Neil (1999) make a similar observation in the context of action learning.

The effectiveness of teamwork during the simulations – in terms of listening, making comments and exchanging ideas – is also a factor that may influence the learning process. Teamwork among the junior, and thus more immature, undergraduate population appeared to be substantially less effective than among the senior undergraduate and postgraduate students (see Table 1). This implies that particularly for the latter team collaboration tends to have positively reinforced the learning process and outcomes.

In view of the objective of this study – exploring the added value of microworlds as educational tool – the last three variables in Table 1 are important. The junior undergraduate students had recently completed secondary education and thus were without any previous experience in academia. These students perceive the added value for learning – in general as well as compared to previous education – to be somewhat lower than the senior students do. Both the senior undergraduate and postgraduate students evaluate the added value of the microworld tool as rather high, also relative to learning experiences in previous courses or when comparing it with experiences in the “real world”.

Insert Table 1 about here

The answers to the *open questions* on the evaluation form illustrate these findings. Many undergraduate respondents describe learning outcomes that incorporate elements of both surface learning (e.g., applying, solving) and deep learning (e.g., understanding, experiencing). For example:

“The microworld provides the opportunity to experience how it feels to manage and lead a business. Insights in system patterns obtained earlier can now be applied in the simulation.”

Several undergraduate students emphasize deep rather than surface learning:

“ The mobile phone microworld was a good introduction which showed what the limits-to-growth archetype is all about. What struck me most in the professional services microworld was the fact that we had to deal with many unexpected things. You can only deal with unexpected events if you really understand how the relations between resources and strategy are.”

Similar comments were made by two participants in the executive MBA-program:

“I particularly liked the set-up of the session around system dynamics and the resource-based framework. Frequently switching from short lecture to simulation assignment to discussion, to lecture and simulation again, and so forth is very effective. It keeps me very alert, it is very different from the normal seminar approach.”

“The simulations were an eye-opener for me. I now really understand the role of intangible resources such as reputation and experience, and how it is affected by marketing and strategy.”

In the undergraduate course Introduction to Business Studies, each team of students wrote and delivered a report on the assignments that also included an assessment of what the team had learned of the work on the microworld assignments. For example, one of the teams in the Introduction to Business Studies course wrote:

“These are really diverse assignments. All components are linked with each other; therefore each decision has its influence on other processes within the company and this makes it interesting. We had to look ahead and think about the consequences of our actions and possible solutions before we could actually see the results. Because we tried a lot of options we found out different ways of running the company. Most of them were not very successful, but you still learn from that.”

Other teams in the same course emphasized a number of practical insights resulting from the work on the Mobile Phone microworld. For example, two typical excerpts are:

“We now realize the strong relations between the different departments. We understand the connection between the higher and lower spending subscribers; if you have too many subscribers compared to service capacity, the higher spending subscribers will probably leave, because the service has to be spread out among more people. Another insight is that cash flow responds almost immediately to decisions, which leads to monthly fluctuations.”

“Marketing is closely connected to operations, especially the capacity. There should be a sort of balance between investments in marketing and investments in capacity. It is not useful to invest large amounts of money in marketing if your capacity cannot cope with the new subscribers. After a short while the number of new subscribers per month will equal the number of leaving customers, because the undercapacity leads to negative word-of-mouth.”

Concluding remarks

There is almost no research that evaluates learning processes in the context of microworld simulations (Maier and Grössler, 2000). Therefore, this paper explored the adoption of microworld simulations as educational tools that may prepare undergraduates for managerial work and deepen and accelerate learning by part-time MBA-students. The implications of adopting microworlds have been outlined, and subsequently data obtained in several courses have been presented and discussed. The findings suggest that, if a number of important facilities and resources are provided, students can be guided toward deeper learning by means of tailor-made combinations of lectures, cases, readings and microworlds. The educational value of this particular form of business simulation appears to arise from the rapid and straightforward feedback given in a microworld simulation and the systems frameworks used for reflection and understanding, but also from the synergy between simulation work and other activities (e.g. readings, discussions, lectures).

The findings in this study also suggest that the educational value of microworlds tends to be perceived more positively by mature undergraduate and postgraduate students than by junior undergraduate students. However, these findings should be carefully interpreted. In this respect, the three groups of students were exposed to different microworlds (mobile phone – mobile phone and professional services – professional services) in course designs with different objectives and delivery modes and different ways of supervising and coaching students.

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Appendix: Overview of two microworlds

Mobile Phone Subscriber Microworld

This microworld focuses on the work of the Marketing and Customer Services (MCS) Director of a mobile phone company. The director has to build the customer-base of subscribers as rapidly as possible, and to ensure this growth is matched by increases in the capacity of the network to meet demand placed on it. Responsibility for the network capacity lies with the Operations Director, who is assumed to do his job well by providing the capacity asked for by the director of MCS.

The system managed by the MCS director can be summarized in terms of the inflow, current number and outflow of subscribers, and the service capacity. It shows how the inflow of new subscribers is determined by marketing investments and word-of-mouth effects. The outflow of subscribers is a result of the 'churn rate', referring to subscribers terminating their contracts to switch to other mobile phone companies or to give up their mobile phone. In addition, subscribers may terminate their contracts as a result of poor service caused by lack of capacity (e.g., call failures, loss of signal). This poor service drives up the churn rate. Service capacity itself is determined by decisions to invest in new capacity, which subsequently comes available after six months. The simulation involves a period of five years, in which decisions on marketing investments and the desired capacity change (in six months) are taken, normally on a monthly basis. Depending on the purpose for which the microworld is used, participants can set different initial conditions (e.g. initial size, word-of-mouth growth rate) or other parameters (e.g. time period: 1 month, 3 months, 1 year).

When using the microworld, participants can ask for different types of information on the computer screen: reports, graphs and tables. The information given can be on revenues, costs and profits (e.g. total or per subscriber), net or cumulative cash flow, actual and target service capacity, gained and lost subscribers, and so forth.

This microworld does not provide a comprehensive view of the mobile phone business, but focuses on a simplified set of issues around growth in the customer base and the network capacity. It is especially useful for introductory courses in the area of, for example, Business Studies, Services Management, Strategic Management or Systems Thinking. The software can be easily installed on any computer system.

Professional Services Microworld

This microworld illustrates the issues faced by firms in sectors such as advertising, accountancy, law and consulting. It is particularly inspired by the development of the strategy consulting firm McKinsey & Company. This microworld provides the experience of managing and developing a professional staff group across several levels of seniority (consultants, managers and partners) and the building, development and retention of a client group who provide work engagements and thus cash flow. Key issues in using this microworld are, first, the need to assure high quality of work for clients in order to build a reputation that will ensure future growth, and second, the financial and motivational incentives to keep staff busy and challenged in order to create the financial surplus that rewards top professionals.

Participants in this microworld take the role of the team of senior partners of a strategy consulting firm, starting in the year 2000, with the assignment to grow the business in size and reputation over the following 30 years. This means they have to (learn to) understand and manage the complex interplay between tangibles such as staff at different levels, number of clients and cash flow, and intangibles such as reputation, experience, knowledge base, quality

of work and promotion prospects. The simulation can be used on different levels of complexity (e.g., with or without a knowledge base) and also entails a large number of extra facilities, such as several pre-installed scenarios illustrating a specific situation. In managing their consulting firm, the partner team can find and analyze data in the area of clients, quality, reputation, staff, workload, funds and knowledge in the form of written reports, graphs or tables.

This microworld involves a comprehensive simulation of the strategic aspects of running a professional services business. It is particularly useful in more advanced courses in Services Management, Strategic Management or Systems Thinking. The software can be easily installed on any computer system.

Source: *User Guides* for Mobile Phone and Professional Services Microworld, Global Strategy Dynamics Ltd., London, 2000.

Table 1: Microworlds as learning tool in three settings: descriptive statistics (mean and standard deviation) for questionnaire items with 1-5 scale.

Variable	Undergraduate junior level (n=162)	Undergraduate senior level (two classes, n=63)	Post-experience level (three classes, n=54)
Microworlds used:	Mobile Phone Subscriber	Mobile Phone Subscriber and Professional Services	Professional Services
Previous experience	1.0 (.0)	1.0 (.0)	1.1 (.2)
User guide	4.2 (.6)	4.2 (.6)	4.1 (.8)
Software	4.1 (.5)	4.0 (.4)	3.8 (.6)
Framework in			
- readings	3.9 (1.1)	4.0 (1.2)	4.0 (.8)
- lectures	4.0 (1.1)	4.0 (1.2)	4.1 (1.0)
Assignments:	4.2 (.9)	4.3 (.9)	3.9 (1.2)
- interesting and useful	3.8 (.7)	4.2 (.7)	3.9 (1.2)
- guidelines	4.2 (.7)	4.1 (1.0)	4.0 (.9)
Feedback by lecturer			
Collaboration in team:	3.2 (1.2)	4.0 (.6)	3.9 (.8)
- listening	2.9 (1.2)	4.5 (.7)	3.8 (.8)
- making comments	3.1 (1.4)	4.1 (.4)	4.3 (.5)
- exchanging ideas			
Added value for learning	3.6 (.7)	4.4 (.5)	4.3 (.6)
Added value relative to previous education / courses	3.4 (.8)	3.9 (1.0)	
Added value relative to real world experience			4.4 (.8)

Endnotes

¹ The overall rating of all classes/courses was above the average rating of courses in the same programs.

² This form is available upon request from the author.

³ The matrix with intercorrelations between variables showed that most variables are not independent of each other. This matrix is available upon request from the author.