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ABSTRACT

Bridging the gap between theory and practice has always been a key issue for students and graduates. The magnitude and scope of subject areas that students at third level institutions have to learn in theory means that visualising them without any practical experience can be very difficult. Understanding the complexity of supply chain networks and how to manage them create a considerable level of difficulty for students and professionals. Theories and applications included in supply chain management subjects are the key to empathise the real challenges. Nevertheless, teaching these theories needs substantial efforts and new innovative approaches to deliver the concepts and assure successful transfer of the learning outcomes.

To complicate things more, the levels of uncertainty and risk within an entire supply chain are still not fully recognised or understood even by industry professionals. Research studies showed the need for more transparency and collaborative approaches to take place among supply chain partners in order to achieve more sustainable operations. Making sure students comprehend the scale of activities and stochastic nature of a supply chain before they carry on their industrial careers is therefore crucial.

Using computer simulation integrated with structured modelling techniques, a detailed, animated and generic supply chain simulation-based learning framework can be developed to incorporate many areas of learning undertaken by students in relation to the supply chain management. Experimenting on the simulation models allow the students to examine quantitatively the impact of changing critical factors (e.g. inventory level, demand, suppliers' lead time) on the performance of supply chain. This paper demonstrates the impact of using interactive simulation technologies in teaching third level education with special reference to supply chain management and discusses the benefits of learning through such a level of immersion.

Keywords – *Supply Chain Management, Interactive Simulation-Based Learning.*

1. INTRODUCTION

The relationship between third level teaching and learning hangs on a delicate balance between a student's willingness and ability to learn and a lecturer's willingness to create an effective learning environment. Maintaining this balance can make all the difference to students' learning experiences in third level education. Palmer (1998) also makes this point in relation to higher education when he states that:

> *"I have no question that students who learn, not professors who perform, is what teaching is all about...teachers possess the power to create conditions that can help students learn a great deal—or keep them from learning much at all" (Palmer, 1998).*

As instructors to the new virtual generation, third level lecturers need to account for the changes brought by this technological revolution (Proserpio and Gioia, 2007). Never has there been a better time for educational institutes to exploit the advances in information communication technologies and other technological breakthroughs. Especially the relationship between teaching and learning and the bridging of the theory/practice gap for college graduates. Instructional technologies, as stated by Newby et al (1996), such as; overhead transparencies, slides, videotapes and computer programmes play an important role in the bridge between learning and teaching. However, over the past few decades, technologies such as overhead projectors, slideshows (apart from PowerPoint), and video have matured and are not a recognised stimulant for today's more digitally orientated students (Sauers and Walker, 2004, OECD, 1996). To help stimulate this new era of students, modern teaching ideologies have embraced certain technologies such as the internet, PowerPoint slides, animation and interactive software. Constructivist learning states that learning is achieved through interaction with the world and is based on interpretation and is aided by information technology (Vrasidas, 2000). Interaction with technology is also a similar theme to active learning, which Kyriacou (1998) says consists of learning activities where students are given certain amounts of autonomy and control over the organisation and direction of the learning activity. Blended learning combines the philosophy of active learning with the potentials of distance learning through the internet (Garrison and Kanuka, 2004). There is huge scope for the use of simulation as an aid to these learning techniques, although there are few if any examples in literature. Apart from maybe in medical (Holzinger et al., 2009), engineering (Felder et al., 2000) and science schools, simulation modelling is one technological advancement in recent years that has still to be embraced by educational institutes (Taylor and Robinson, 2006). Business modules, including supply chain management, are one area that this embracement can be most effectively achieved.

Understanding the magnitude and complexity of supply chain networks and how to manage them creates a considerable amount of difficulty for students and practitioners alike. Supply chain experimentation and decision making in the real world can have detrimental effects (such as distorted and amplified supply and demand) on companies when they go wrong (Holweg and Bicheno, 2002). In the academic world, visualising and understanding the size and complexity of supply chains has always been an issue. Using computer simulation coupled with conceptual modelling techniques, a detailed, animated and generic supply chain simulation framework can be developed to incorporate many areas of learning undertaken by students in relation to the supply chain management. Experimenting/playing on the simulation models allow the students to examine quantitatively the impact of changing critical factors such as inventory level and lead-times on the performance measures within the supply chain.

2. CHALLENGES TO THE THIRD LEVEL TEACHING LEARNING PROCESS

There have been many academic references on the traditional aspects of educational teaching and learning in literature. In traditional teaching, the success of college graduates was often predicted by the amount of knowledge students had accumulated during their degree (Knight and Wood, 2005). O'Neill et al (2005) say that a lecturer in the traditional setting informed students instead of transforming them, while Rainer and Guyton (1994) characteristic the traditional university course by its lack of flexibility in terms teaching content. Each author has one essential thing in common; traditionally teaching was fundamentally thought about in relation to information transfer between teacher and student only. This learning process was typically believed by past academics to consist of a knowledgeable educator on a particular topic, who constructed and communicated knowledge on such topics to learners using the common instructional technologies of the day; books, articles and classroom lectures (Ruben, 1999). This form of "rote learning" was suggested to be outdated and aversive as early as the studies of Dr. B. Skinner in the 1950's (Skinner, 1954).

In the past, accepting that the relationship between teaching and learning is limited to these mediums and communication channels resulted in huge challenges for education at third level education institutes (Ruben, 1999). Dewey argued that education is based on the interaction of an individual's external and internal environments. Learning activities in constructivism are characterised by active engagement in the classroom, collaboration with others, inquiry, reflective thinking and problem solving (Kesal, 2003).. The differences between traditional and constructivist education methods are shown in Table 1.

During the past 30 years, third level education has been experiencing a revolution. The objectives of schools and faculties have changed. Memorising facts and Figures are now recognised to be less important than developing knowledge based skills for; problem-solving, interactive team work and life-long learning (Kesal, 2003, Knight and Wood, 2005). The introduction of the learning pyramid (Figure. 1) has instilled a new focus on the way teachers interact with students in relation to the retention of what is being taught (DeKanter, 2004).

In brief, the pyramid suggests that over 90% of all learning retention is achieved by participants who practically use theory learned immediately, and then teach it back to each other in group work sessions and presentations (O'Neill et al., 2005). This is in contrast to the 5% retention rate given to the traditional rote learning process of the class lecture. Sections 3 and 4 of this paper will discuss the influence simulation and modelling technologies have on optimising the retention capabilities of students teaching back, as illustrated in the learning pyramid. This study has the potential to optimise the learning retention of third level students by over 70 % (Figure. 1).

Table 1. The differences between Traditional and Constructivist Education Methods

(Rainer and Guyton, 1994)

TRADITIONAL EDUCATION	CONSTRUCTIVIST EDUCATION
Imposition from above	Expression and cultivation of individuality
External discipline	Free activity
Learning from texts and teachers	Learning through experience
Acquisition of isolated skills and techniques by drill	Acquisition of skills as means of attaining ends which make direct vital appeal
Preparation for more or less remote future	Making the most of opportunities of present life
Static aims and materials	Acquaintance with a changing world

3. INNOVATIONS IN TEACHING AND LEARNING TECHNIQUES

Learning is an iterative process loop. The learning loop is a process of ongoing refinement of a conceptualise-construct-identify pattern, with dialogue playing a central role in each stage (Fowler and Mayes, 2000). This process is articulated in an earlier study by Laurillard who places the iterative sequence of the ideal teaching and learning process in a four-stage model shown in Table 2 (Kesal, 2003). This theory is similar to the stages in the teaching skill acquisition cycle used in third level teacher training as illustrated in Figure 2 (Perrott, 1998).

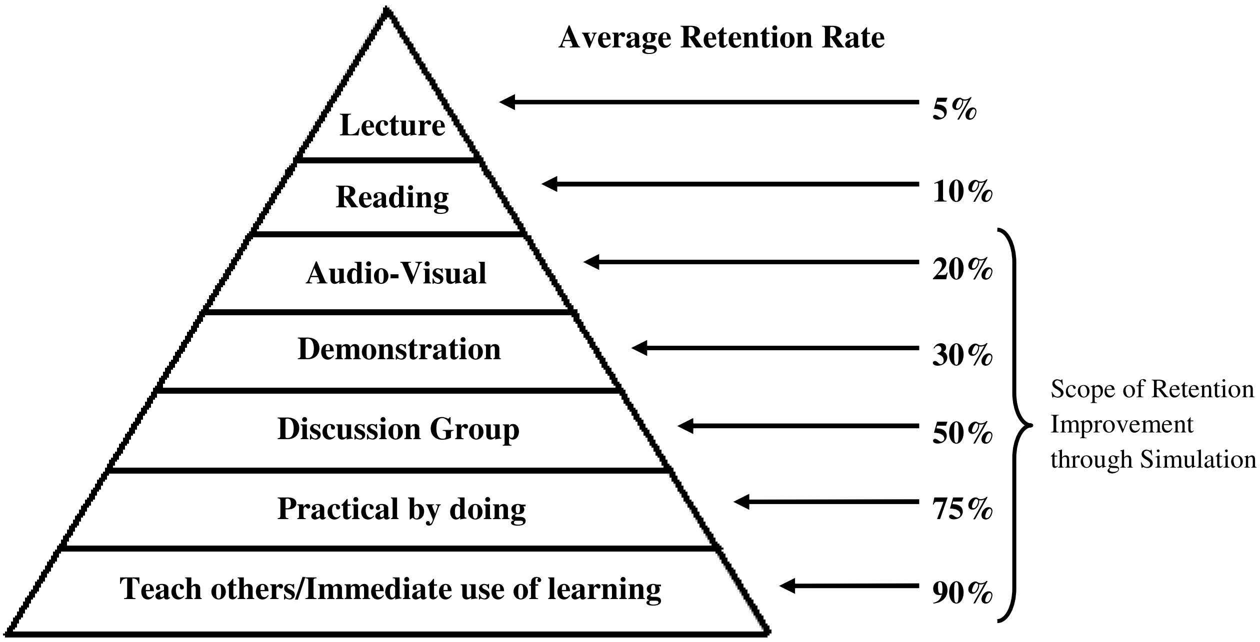

Figure 1. The Learning Pyramid (O'Neill et al., 2005)

Table 2. Characteristics of the ideal teaching/learning process *(Kesal, 2003)*

Discussion	Between teacher and learner at the level of descriptions
Interaction	Between the learner and some aspect of the world defined by the teacher
Adaptation	Of the world by the teacher and action by the learner
Reflection	On the learner's performance by both teacher and learner

Both theories put an important emphasis on key elements of understanding the practical aspects of what was learned in theory. That is; discussing what was learned; interaction within the class on what was learned; adapting this knowledge for a better understanding; and reflecting on what the learning outcome achieved to improve the learning process. Active learning as discussed by Prince (2004) and Kyriacou (1998) also associates the same theme of a more interactive, collaborative and cooperative approach to learning. Problem based learning (PBL) is another technique that also allows the student to interact with a theoretical problem in a more practical real life way using the ideology of active learning, especially in medical schools (Chan, 2009, Prince, 2004).

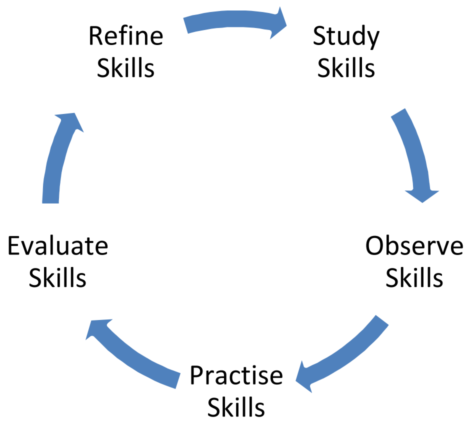

Figure 2. Stages in Skill Acquisition (Perrott, 1998)

There have been many technological innovations in recent times to aid this. Over head projectors and PowerPoint slide presentations are the most commonly used. But there also more complex methods such as distance learning, online learning and a combination of information technology with traditional teaching called blended learning. At its basic level, blended learning is the integration of face-to-face classroom learning experiences with online learning experiences, (Garrison and Kanuka, 2004). Wireless keypads (Burnstein and Lederman, 2001) and audience response systems (ARS) or clickers (Caldwell, 2007) have also aided in the transformation of the third level lecture. The use of gaming technologies is becoming more popular method of teaching theory with a practical edge. Medical, nursing, engineering and business schools have been at the forefront in advancing this learning process (van der Zee and Slomp, 2009, Ferdig et al., 2007).

3.1 Simulation as a Teaching Aid

Today's third level students are of the virtual age, were online multi-player games, virtual reality and simulations are a part of everyday life, making gaming and simulation a very important catalyst in the learning process (Proserpio and Gioia, 2007, Ferdig et al., 2007). There have been very few examples of the gaming and simulation theory being used in third level education. The most popular being the beer game introduced by MIT in 1960 as an exercise in industrial dynamics (Iyer et al., 2009). Some academics say that the medium of games have been under utilised by educators, with institutes focusing on negative social consequences while ignoring the important potential of gaming and simulation as teaching aids (Squire, 2003). Little has changed since the beer games introduction. There have been some advances in gaming and simulation education such as; van der Zee and Slomp's assembly line simulation game (2009) and the activity-based-costing (ABC) flash simulator game developed by McKee and Lantz (2009). Although very effective in visualising and simulating the fields of production processes and costing they do not have the scope to incorporate all areas of a supply chain. Simulation has huge potential to be a very effective tool in teaching the practical operations of SCM. As Figure 3 illustrates, simulation can be used as a link between the active learning of constructivism and the hands on experience of real-life practice.

Two factors should be taken into account while designing a simulation environment for education: interaction between the environment and the learner and graphics design. Designing a suitable learning environment depends on the learner and the material which will be provided (Dix *et al*., 1998). Suitability, resources and risk should also be considered (Moizer *et al*., 2009). Involving the user in the very early stage of design is a very important rule to guarantee a high level of usability. A certain level of immersion in simulation environment tools helps in increasing the liability of the students gaining more knowledge while using the designed system.

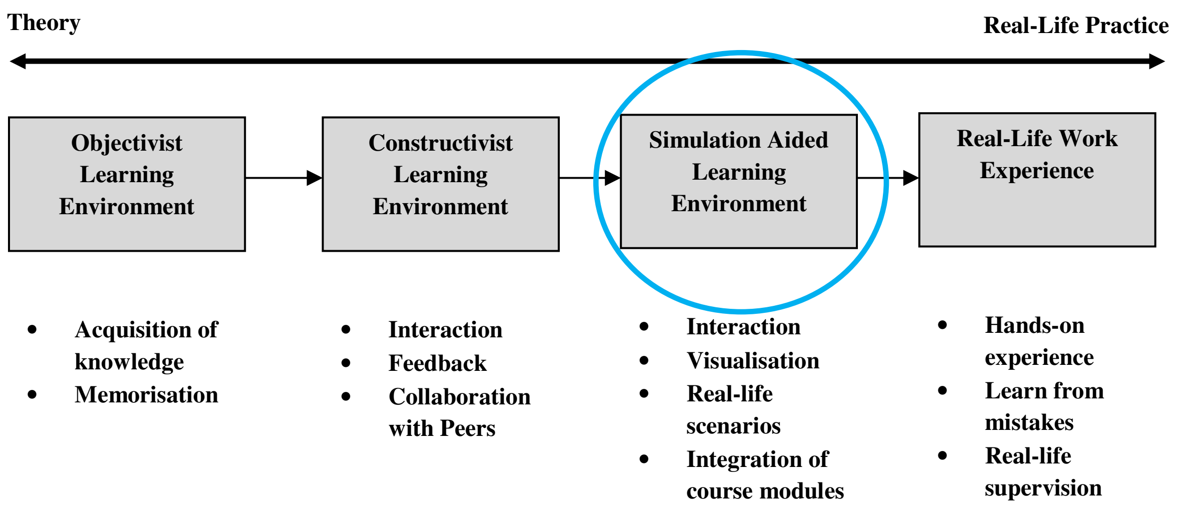

Figure 3. Simulations Link between Theory and Real-Life Practice. (*Adapted from Bond (2002)*)

A high growth rate of interest in games and interactive graphical user interface programs between students gives a good chance for a simulation tool to take a place in an education environment. Growth in the gaming and simulation industry and the increasein the average hours spent by people in front of computers has resulted in students being more familiar with using a GUI simulation tool for learning. One of the challenges is how to embed enough knowledge in the designed tool.

One of the most important key factors in the learning process is the cooperative learning process (e.g. learning pyramid). It can be achieved by encouraging students to work together to achieve a certain goal. This can evolve the communication skills between students and helps in knowledge retention. Interactive simulation tools enable students to work in groups, apply and check different scenarios, discuss the results together. Testing without pain which is an aspect of the simulation systems breaks the fear in students to apply any scenario they may think about and increases the level of excitement when the results outcome.

4. SUPPLY CHAIN MANAGEMENT (SCM)

SCM has grown in importance at an exponential rate since the early 1990s, even though the approach was first introduced in early 1980 by Oliver and Webber, cited in (Jüttner et al., 2007). As a management philosophy, it is a very vast concept, with many interpretations and definitions. SCM can be defined as the management of upstream (suppliers) and downstream (customers) relationships in order to create enhanced value in the final market place at less cost to the supply chain as a whole (Christopher, 1998).

The fuel supply chain in Figure 4 illustrates very effectively the relationship between upstream and downstream partners; information (the order cycle) flows both directions, downstream is the flow of fuel to the end user, whereas upstream is the flow of capital to finance the chain. It shows a strategic collaboration between business partners to commit to close supply chain relationships to bring greater value to the end consumer and their customers for the least possible supply cost (Hung et al., 2004).

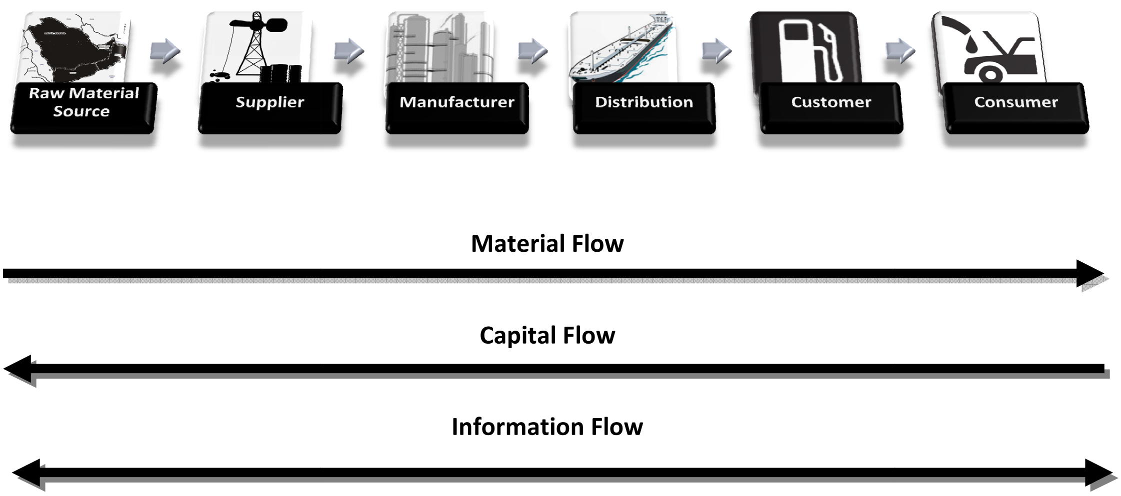

Figure 4. The Fuel Supply Chain

At its basic level a supply chain is made up of multiple actors, multiple flows of items, information and finances (Longo and Mirabelli, 2008). The authors add that each network node has its own customers' and suppliers' management strategies, demand arrival process and demand forecast methods, inventory control policies and items mixture. Conceptually modelling such a network is the optimum way to visualise the complexity of a supply chain (Hung et al., 2004). The conceptual model of a furniture manufacturing company's supply chain illustrated in Figure 5 is very effective in highlighting the complexity of a supply network.

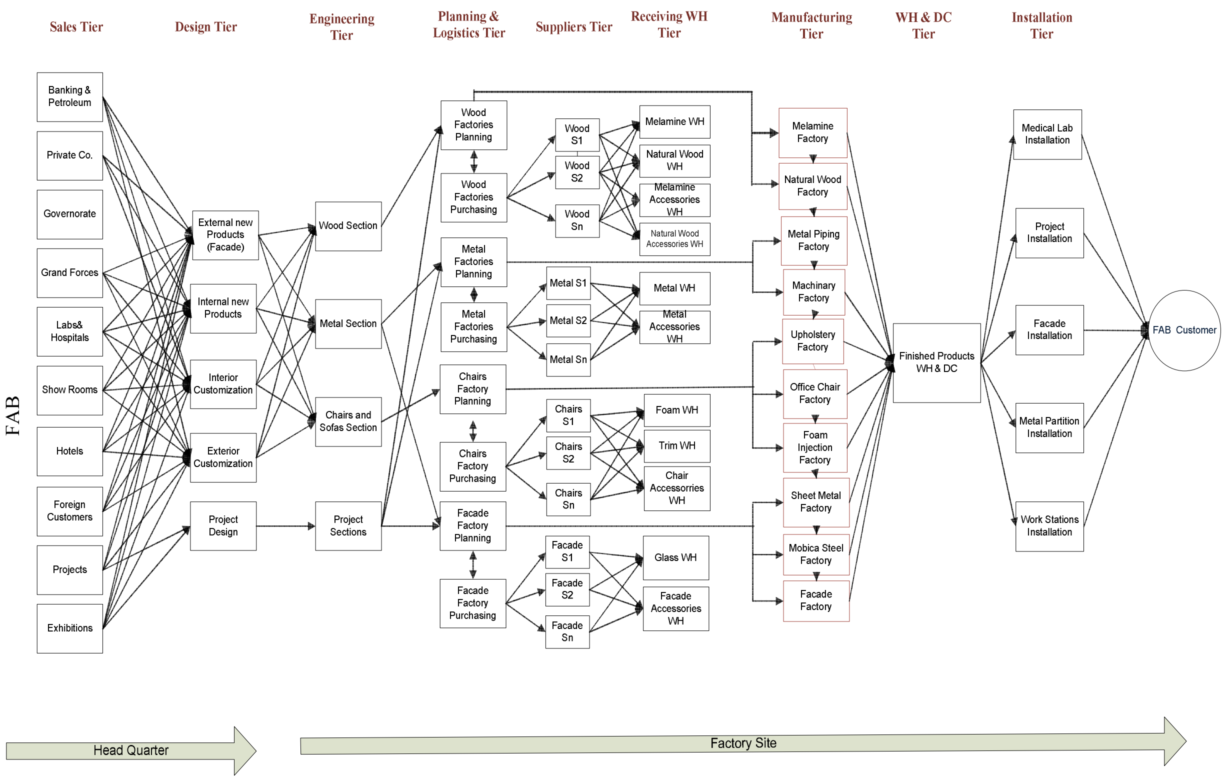

Figure 5. Furniture Manufacturer Supply Chain (Mahfouz, 2010)

In this one distribution channel, excluding external partners, there are a total of 66 network nodes and hundreds of potential material and information paths. Research has shown that understanding the magnitude of such systems (and the relationships and partnerships needed to successfully operate them) is a concept many professional practitioners do not understand or fully appreciate (Christopher, 1998, Barratt, 2004, Spekman et al., 1998), never mind first year undergraduate business students. A conceptual demonstration of the potential of simulation as a support tool in the teaching of SCM will be developed in Section 4.1.

4.1 Teaching SCM using Simulation Technology

The central theme through this paper has been investigating the potential of using interactive simulation technologies to facilitate learning concepts of supply chain management. The advances in simulation educational innovations such as the beer game and ABC simulator noted in section 3.1 have been found to be very effective in aiding teaching of certain tiers of a supply chain network such as distribution, material movement and costing. However, they lack the fundamental ability to effectively visualise and demonstrate the operations of the whole supply chain; from the source of raw material to the delivery to the end consumer (Figure. 4). Although, there are some simulated supply chain models developed that incorporate a broader scope of SCM, such as; Longo and Mirabelli's (2008) SCM decision support tool and Rossetti et al's (2008) object-orientated framework for simulating supply systems. But it is important to note that these models were developed as analytical decision making tools for supply chain managers and do not have the required interaction, animation, or academic attributes that would stimulate the mind of a third level student.

Using the conceptual model of the furniture supply chain (Figure. 5), a framework was developed (Figure. 6) to assist in the future creation of an actual simulation based teaching aid to third level SCM lecturers. The framework consists of 5 main categories to achieve a complete and practical understanding of a global supply chain. They are; (1) SCM variables; (2) hierarchical conceptual modelling; (3) simulation; (4) optimisation; and (5) SCM decisions.

SCM Variables - Factors that will influence the outcome of a supply chain strategy, any simulation run or the building of a conceptual model. There are three distinct management levels to consider; strategic, tactical and operational (Gunasekarana et al., 2004). The strategic level (5-10 years) influences top level management decisions, very often reflecting broad based policies, corporate financial plans, competitiveness and level of adherence to organisational mission, vision and goals. The tactical level (1-5 years) deals with resource allocation and measuring performance against targets to be met in order to require accurate data and assess the results of decisions of low level managers for daily operations and scheduling.

Hierarchical Conceptual Modelling - A form of business process modelling (BPM), conceptual modelling is a presentation of the sequences of system processes, procedures and resources and shows the relationship between a system's objects, such as customers and products, and their status during the systems process (Mahfouz et al., 2010). They are essential in clearly understanding any system or process that needs simulated. Effective hierarchal methods include integrated definition for functional modelling (IDEF) family, particularly IDEF0 (Strategic) and IDEF3 (Operational), supported by flowcharts and dataflow diagrams (Aguilar-Savén, 2004). A generic supply chain conceptual modelling technique has also been develpoed, (Longo and Mirabelli, 2008). The conceptual model of the furniture supply chain (Figure. 5) is an example of a Level 0 view of a supply chain, or in terms of the framework (Figure. 6), a strategic level model. Each individual node at level 0 would be a tactical level, e.g. manufacturing plant, which in turn would filter down to operational activities such as inventory management as shown in Figure 7. It will be this level of operational activity that will be used to demonstrate how student can interactively learn through simulation. If students create the conceptual models themselves, they will also begin to understand the structure of SCM more.

Simulation – Simulation-based learning approaches aim to imitate a system, entity, or process and try and bridge the theory/practice gap (Lean et al., 2006). They attempt to

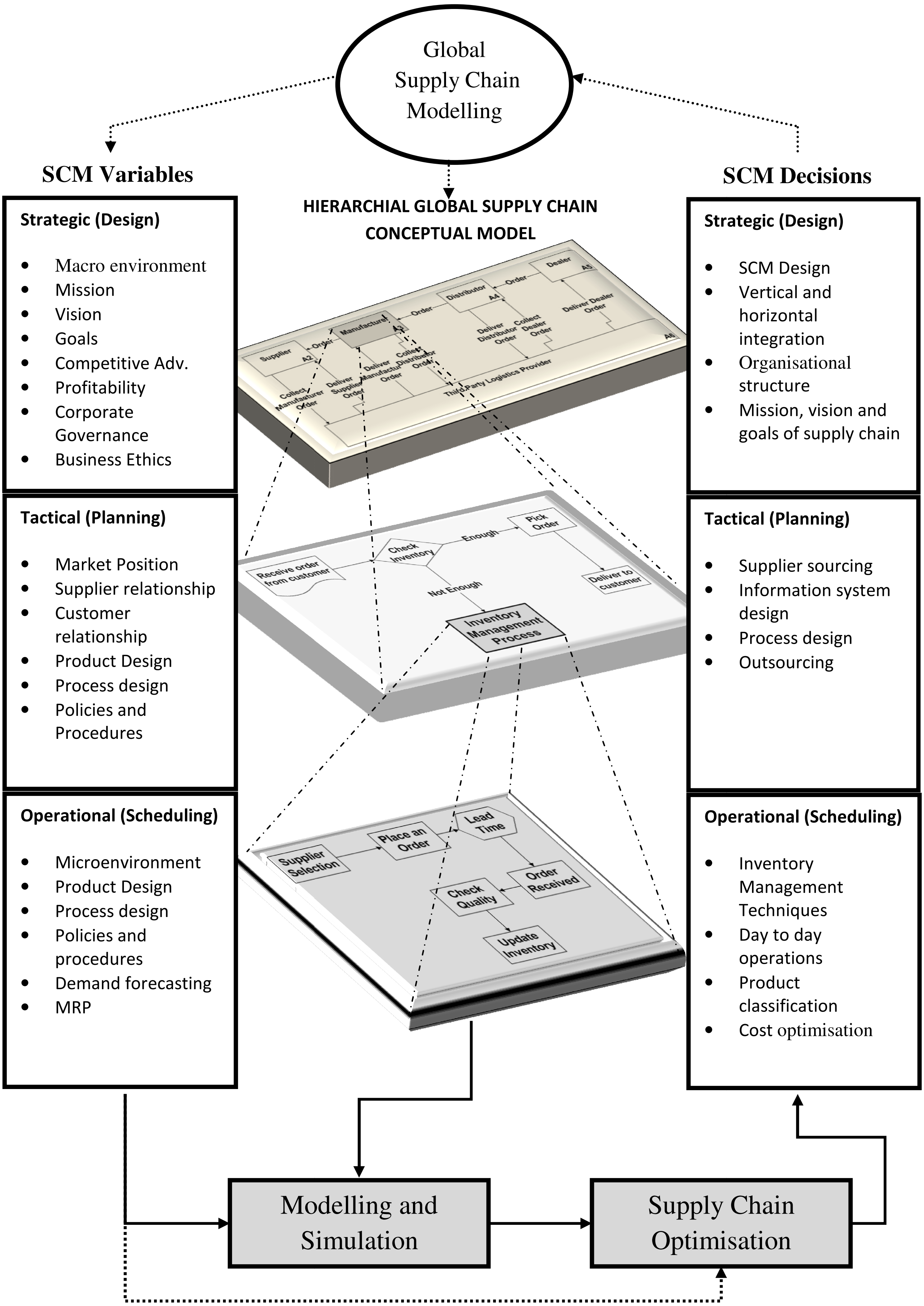

Figure 6. Simulation-Based Learning Framework

represent or predict aspects of the behaviour of the problem or issue being studied, in this case SCM. Simulation can be classified according to many characteristics including; stochastic (input data is random) or deterministic (input data is fixed), static (time has no role) or dynamic (time plays an essential role) and continuous (system state changes continuously) or discrete (events that occur at separate times) (Aguilar-Savén, 2004, Holt, 2005). The majority of supply chains follow a discrete event path, but as every system has a start and a finish with some sort of supply required, whether a tangible product or intangible service/information, all characteristics of simulation modelling can be referred to through SCM.

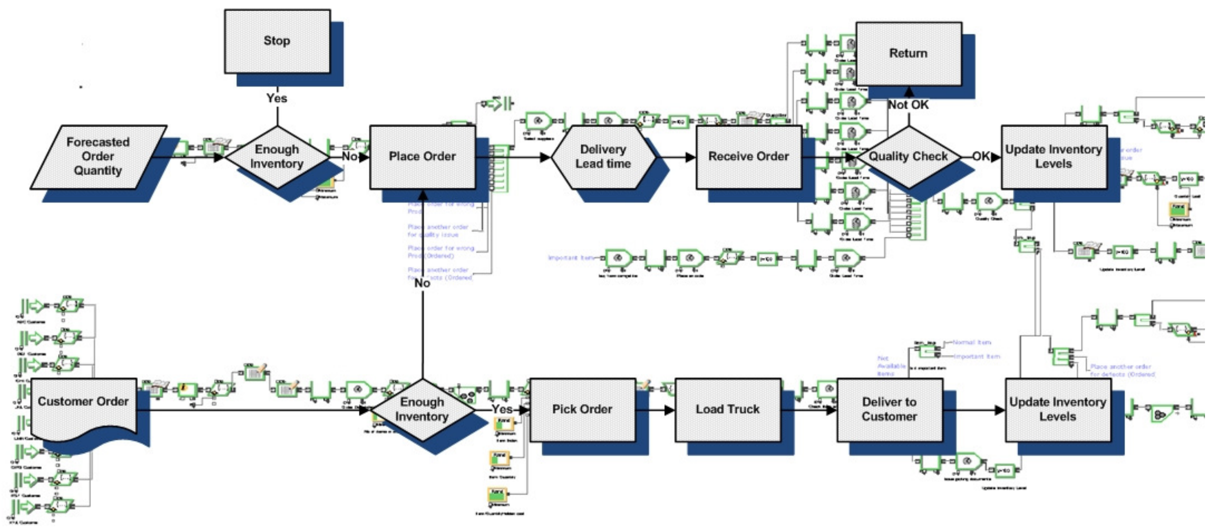

Figure 7. Simulation Model of Inventory System

It is clear that using simulation as a teaching aid in describing a supply chain is also a valuable way that allows students to learn and understand the fundamental characteristics of supply chain networks. Simulation can allow experiments to be conducted within a fictitious situation to show the real behaviours and outcomes of possible conditions (Lean et al., 2006). For example, if the simulation model for inventory management in Figure 7 is introduced in a classroom environment, a student could; manage the inputs of the order cycle (resources such as labour and forklifts, lead-times, re-order points, safety stock etc.); decide on the inventory management technique to use (economic order quantity etc.); and distribute demand (normal distribution, exponentially etc).

Optimisation - There are two main optimisation performance categories in SCM:

i. Quantitative – such as re-fill rates, costs, inventory levels, capacity constraint and resource utilisation.
ii. Qualitative – customer satisfaction, product quality,, supply chain risk and vulnerability and supply chain resilience (Longo and Mirabelli, 2008).

Using optimisation, students can run several simulation scenarios to find the best results on any of the above performance measures. Swhartz *et al*. (2006) state that the use of optimisation in supply networks has been around for a long time. From the introduction of the economic order quantity model in the 1930's (Wilson, 1934), to the "order up to" policy (Glasserman and Tayur, 1995) and the model predictive control technique (Blanchini et al., 2004). Calculating the optimal results is a very important aspect of SCM, its philosophy is after all is to minimise total costs while increasing customer satisfaction (see definition in section 4). Students can also see how theoretical statistical equations they have learned in other course modules including; linear programming, critical path analysis, triangulation, transportation algorithms, Pareto analysis and activity based costing (ABC) are used in real-life practice. It gives a very practical grasp on the importance of what they are learning at third level.

The results shown in Figure 8 are from the inventory management simulation model (operational level) illustrated in Figure 7.

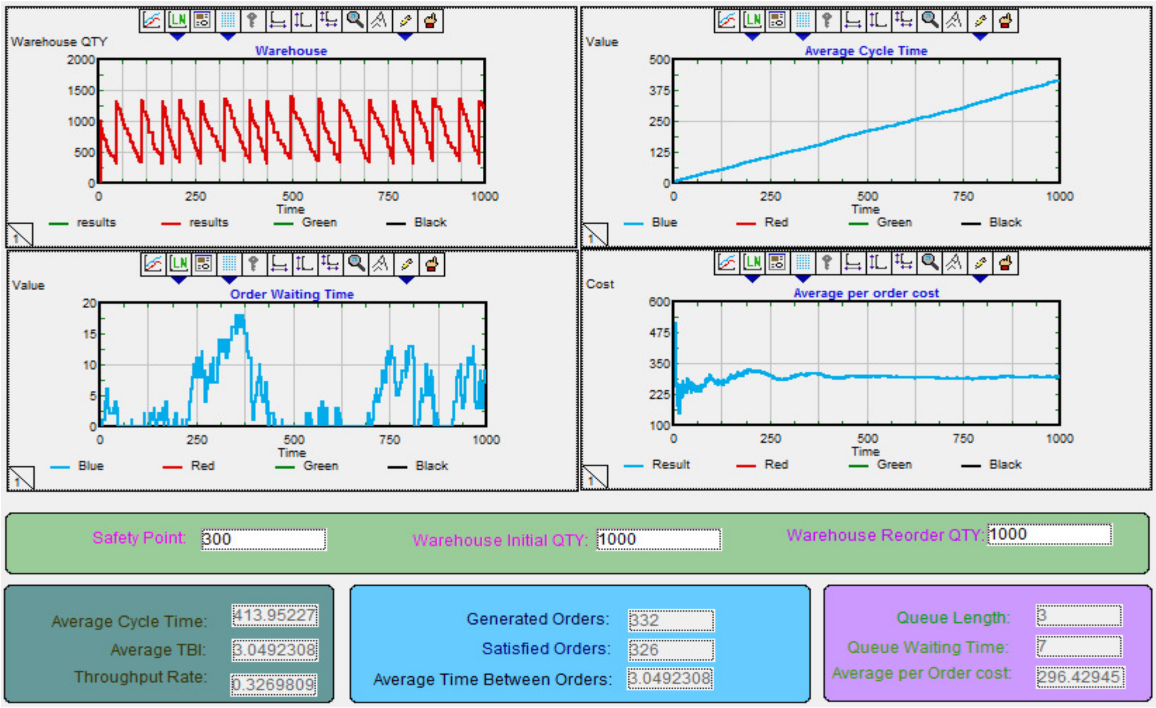

Figure 8. Inventory Management Simulation Model Results

This is an important aspect of the simulation-based learning framework, as it visually and quantitatively highlights the consequences of the students input decisions on certain outputs such as; throughput rate, average total costs and cycle time.

SCM Decisions – The model helps decisions-makers on strategic, tactical and operational levels by providing set of simulation and optimisation results. These can be day-to-day operational decisions like what are required for the planning system; more tactical decisions such as the make or outsource decision; and/or strategic decisions including the changing of the company mission, and vertical and horizontal integration. This gives third level students a chance to act in the role of supply chain manager, a position they will one day be in.

5. LIMITATIONS

This paper presents a conceptual framework of using simulation-based learning technique in education. Some limitations could be faced when applying this framework on other fields of knowledge due to the lack of modelling techniques to express certain management problems.

Design techniques could suffer from ineffective GUI and usability facilities which lead to low level of interaction and immersion system.

6. CONCLUSION

With the dramatic increase in computer aided designs, the internet and web, the designing of new tools for teaching and training purposes has become inevitable. Studies and statistics have shown that knowledge retention period and knowledge gain rate increases by using visual and cooperative aids. Gaming and simulation environments present a rich resource to achieve a new progress rate in the third level education process. Traditional learning processes have not embraced these new technological advances and the new learning techniques such as blended and active learning have not utilised the potential of simulation-based learning.

For this reason, a simulation-based learning framework has been chosen because of its unique aspects to capture the attention of the virtual student generation. Through a modelling and simulation tool, a system has been designed and developed to assist teaching of SCM concepts. The third level student and the conducted material - SCM concepts – have been taken into account while building the system and designing the graphical user interface. A good usability level, interaction facilities and descent result displays have been arranged to help students work on the system, apply different scenarios and trace the consequential outputs.

Few constraints could be faced due to the limitations of modelling techniques to capture uncertainty embedded in SC networks. The presented framework establishes a foundation to build on for other knowledge disciplines. This paper has resulted in the acknowledgment that there is strong potential for future development of both academic and professional simulation-based SCM education tools.

Using simulation-based learning environments allows students as well as practitioners to change inputs and examine the resulting outputs without making real-life disruptions to supply chain operations; simply it is experimenting without pain.

REFERENCES

AGUILAR-SAVÉN, R. S. 2004. Business process modelling: Review and Framework. *International Journal of Production Economics,* 90**,** 129-149.

BARRATT, M. 2004. Understanding the meaning of collaboration in the supply chain. *Supply Chain Management: An International Journal,* 9**,** 30-42.

BLANCHINI, F., MIANI, S. & RINALDI, F. 2004. Guaranteed cost control for multi-inventory systems with uncertain demand. *Automatica,* 40**,** 213-223.

BOND, A. 2002. Learning music online: An accessible learning program for isolated students. *In:* AUTHORITY, A. N. T. (ed.). Leabrook: National Centre for Vocational Education Research (NCVER).

BURNSTEIN, R. A. & LEDERMAN, L. M. 2001. Using Wireless Keypads in Lecture Classes. *The Physics Teacher* 39**,** 8-11.

CALDWELL, J. E. 2007. Clickers in the Large Classroom: Current Research and Best-Practice Tips. *Life Sciences Education,* 6**,** 9-20.

CHAN, E. A. 2009. Reflecting on the essence of our problem-based learning discussions: teh importance of faculty develpoment and our continuous quest for applications of problem based learning. *Kaohsiung Journal of Medical Science,* 25**,** 276-281.

CHRISTOPHER, M. 1998. *Logistics and supply chain management: Strategies for reducing cost and improving service,* London, Financial Times Publishing.

DEKANTER, N. 2004. Gaming Redefines Interactivity for Learning. *TechTrends,* 49**,** 26-31.

DIX, A. J., FINLAY, J. E., ABOWD, G. D. & BEALE, R. 1998. *Human-Computer Interaction,* London, Prentice Hall.

FELDER, R. M., WOODS, D. R., STICE, J. E. & RUGARCIA, A. 2000. THE FUTURE OF ENGINEERING EDUCATION II. TEACHING METHODS THAT WORK. *Chemical Engineering Education,* 34**,** 26-39.

FERDIG, R. E., COUTTS, J., DIPIETRO, J. & LOK, B. 2007. Innovative technologies for multicultural education needs. *Multicultural Education & Technology Journal,* 1**,** 47-63.

FOWLER, C. H. & MAYES, J. T. 2000. Learning relationships from theory to design. *Association of Learning Technology Journal,* 7**,** 6-16.

GARRISON, R. D. & KANUKA, H. 2004. Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education,* 7**,** 95-105.

GLASSERMAN, P. & TAYUR, S. 1995. Sensitivity analysis for base-stock levels in multiechelon production–inventory systems. *Management Science,* 41**,** 263-281.

GUNASEKARANA, A., PATELB, C. & MCGAUGHEY, R. E. 2004. A framework for supply chain performance measurement. *International Journal of Production Economics 87,* 87**,** 333-347.

HOLT, J. 2005. *A Pragmatic Guide to Business Process Modelling,* Swindon, British Computer Society.

HOLWEG, M. & BICHENO, J. 2002. Supply chain simulation } a tool for education, enhancement and endeavour. *International Journal of Production Economics,* 78**,** 163-175.

HOLZINGER, A., KICKMEIER-RUST, M. D., WASSERTHEURER, S. & HESSINGER, M. 2009. Learning performance with interactive simulations in medical education: Lessons learned from results of learning complex physiological models with the HAEMOdynamics SIMulator. *Computers & Education,* 52**,** 292–301.

HUNG, W., KUCHERENKO, S., SAMSATI, N. & SHAH, N. 2004. A flexible and generic appraoch to dynamic modelling of supply chains. *journal of Operational Reesearch Society,* 55**,** 801-813.

IYER, A. V., SESHADRI, S. & VASHER, R. 2009. *Toyota Supply Chain Management,* New York, McGraw-Hill.

JÜTTNER, U., CHRISTOPHER, M. & BAKER, S. 2007. Demand chain management-integrating marketing and supply chain management. *Industrial Marketing Management,* 36**,** 377-392.

KESAL, F. 2003. *An investigation on constructivist classroom characteristics in ELT methodology II courses.* PHD, Middle East Technical University.

KNIGHT, J. K. & WOOD, W. B. 2005. Teaching More by Lecturing Less. *Cell Biology Education,* 4**,** 298-310.

KYRIACOU, C. 1998. *Essential Teaching Skills,* Cheltenham, Stanely Thornes (Publishers) Ltd.

LEAN, J., MOIZER, J., TOWLER, M. & ABBEY, C. 2006. Simulations and games: Use and barriers in higher education. *Active Learning in Higher Education,* 7**,** 227–242.

LONGO, F. & MIRABELLI, G. 2008. An advanced supply chain management tool based on modeling and simulation. *Computers & Industrial Engineering,* 54**,** 570-588.

MAHFOUZ, A. 2010. FAB Funiture Manufacturer Supply Chain Conceptual Model. Dublin: 3S Group, Dublin Institute of Technology.

MAHFOUZ, A., ALI HASSAN, S. & ARISHA, A. 2010. Practical simulation application: Evaluation of process control parameters in Twisted-Pair Cables manufacturing system. *Simulation Modelling Practice and Theory,* 18**,** 471-482.

MCKEE, J. A. & LANTZ, K. A. 2009. The ABC Simulator: A New Approach to Teaching Traditional Topics. *Management Accounting Quarterly,* 10**,** 28-33.

MOIZER, J., LEAN, J., TOWLER, M. & ABBEY, C. 2009. Simulations and games: Overcoming the barriers to their use in higher education. *Active Learning in Higher Education,* 10**,** 207–224.

NEWBY, T. J., STEPICH, D. A., LEHMAN, J. D. & RUSSELL, J. D. 1996. *Instructional Technology for Teaching and Learning,* New Jersey, Prentice Hall.

O'NEILL, G., MOORE, S. & MCMULLIN, B., (EDS) 2005. Teaching and learning activities: Expanding the repertoire to support student learning. *In:* (HEA), H. E. A. I. (ed.). Dublin: All Ireland Society for Higher Education (AISHE).

OECD 1996. *Information technology and the future of post-secondary education,* Paris, Organisation for Economic Co-operation and Development (OECD).

PALMER, P. J. 1998. *The courage to teach : exploring the inner landscape of a teacher's life* San Francisco, Jossey-Bass.

PERROTT, E. 1998. *Effective Teaching, a practical guide to improving your teaching* Harlow, Addison Wesley Longman Limited.

PRINCE, M. 2004. Does Active Learning Work? A Review of the Research. *Journal of Engineering Education,* 93**,** 223-231.

PROSERPIO, L. & GIOIA, D. A. 2007. Teaching the Virtual Generation. *Academy of Management Learning & Education,* 6**,** 69-80.

RAINER, J. D. & GUYTON, E. 1994. Developing a Constructivist Teacher Education Program: The Policy-Making Stage. *Journal of Teacher Education,* 45**,** 140-151.
ROSSETTI, M. D., MIMAN, M. & VARGHESE, V. 2008. An object-oriented framework for simulating supply systems. *Journal of Simulation,* 2**,** 103-116.
RUBEN, B. 1999. Simulations, games, and experience-based learning: The quest for a new paradigm for teaching and learning. *Simulation & Gaming,* 30**,** 498-505.
SAUERS, D. & WALKER, R. C. 2004. A COMPARISON OF TRADITIONAL AND TECHNOLOGY-ASSISTED INSTRUCTIONAL METHODS IN THE BUSINESS COMMUNICATION CLASSROOM. *Business Communication Quarterly,* 67**,** 430-442.
SCHWARTZ, J. D., WANG, W. & RIVERA, D. E. 2006. Simulation-based optimization of process control policies for inventory management in supply chains. *Automatica 42 (2006) 1311 – 1320,* 43**,** 1311-1320.
SKINNER, B. F. 1954. The Science of Learning the Art of Science. *Harvard Educational Review,* 24**,** 86-97.
SPEKMAN, R., KAMAUFF, J. & MYHR, N. 1998. An empirical investigation into supply chain management: a perspective on partnership. *Supply Chain Management,,* 3**,** 53-67.
SQUIRE, K. 2003. Video Games in Education. *International Journal of Intelligent Simulations and Games,* 2**,** 49-62.
TAYLOR, S. & ROBINSON, S. 2006. So where next for simulation? A survey of the future for discrete-event simulation. *Journal of Simulation,* 1**,** 1-6.
VAN DER ZEE, D. J. & SLOMP, J. 2009. Simulation as a tool for gaming and training in operations management - a case study. *Journal of Simulation,* 3**,** 17-28.
VRASIDAS, C. 2000. Constructivism versus objectivism: Implications for interaction, course design, and evaluation in distance education. *International Journal of Educational Telecommunications,* 6**,** 339-362.
WILSON, R. H. 1934. A Scientific Routine for Stock Control. *Harvard Business Review,* 13**,** 116-128.