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USING MULTIMEDIA AND INTERACTIVE GAMES TO ENHANCE STUDENTS' UNDERSTANDING OF SCM

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Abstract
It is challenging to teach supply chain management (SCM) practices and technologies to tertiary students. This is because the back-end and highly dynamic processes can be difficult to visualise and because many students only have experience as a consumer. This paper reports the authors' experiences using a variety of multimedia and interactive enhancements we have used with our SCM learning materials: SCM business simulations; online learning modules with interactive games; and multimedia resources such as videos and animations. The paper also provides an overview of the challenges faced using these approaches, which gives rise to a number of future research opportunities. It also argues that these approaches can support educators with any epistemological view of learning. The paper makes a significant contribution because there has been little if any research into the use of these approaches in SCM education.

Key Words: supply chain management; tertiary education; multimedia; interactive games

1. Introduction

The field of supply chain management (SCM) is diverse and draws together multiple disciplines including:

- information systems [1, 2] (eg, the use of electronic messaging to expedite information flows within and between organisations) and electronic business (eg, new forms of supply chain interaction such as via electronic marketplaces);

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logistics [3] (eg, practices which improve the handling of inbound and outbound logistics such as quick response);

- management [4, 5, 6] (eg, developing inter-organisational trust to facilitate collaborative planning and forecasting) and human resources [7] (eg, management of change associated with new business processes).

This complexity of the SCM field presents a number of challenges for tertiary educators who aim to expose students to SCM knowledge. For example, Bodoff & Forster [8] explain that it can be difficult for IS students to learn about eMarkets because they need to conceptualise the dynamics of buyer and seller trading; and to understand economic market theory which they typically have never seen before. SCM education, especially from an IS and eBusiness perspective, is made even more complex because of the back-end nature of many SCM processes and technologies [see also 9]. We believe this is significant because the only experience many tertiary students have had with supply chains is purely as a consumer. Often their exposure to the bullwhip effect comes from encountering out-of-stock items on retail shelves.

There are many ways to enhance the classroom teaching (such as lectures and tutorials) of tertiary students SCM, all of which have their own advantages and disadvantages. For example, a common approach is to use static content (eg, text and diagrams) which can be developed relatively quickly, but cannot easily show dynamic information and materials flows throughout a supply chain. An approach receiving increasing attention by researchers and SCM educators is computer- and Internet-based business simulations in which each student assumes the role of a firm in a supply chain [10, 11, 12, 13, 14, 15, 16, 17, 18]. This research provides evidence that students perceive they gain greater understanding of SCM as a result of participating in these simulations. However, Parker [19] argues that these more sophisticated simulation-based approaches also have disadvantages. For instance, developers find them time-consuming and complex to build. For educators there is the time required to configure and maintain the complex simulation software [19] and the perception that the available simulations are not directly usable within their educational context or learning environment.

We believe that another viable way to enhance SCM education is through the use of multimedia (such as small animations, video interviews) and learning modules which include interactive games. However, there is no SCM research concerning the use of such approaches and the experiences of educators and students. The objective of this paper, therefore, is to report on our experiences using interactive learning modules and multimedia (including the advantages and challenges we faced), and to provide an overview of the anecdotal findings from students who used these learning resources.

The paper is structured as follows. First we summarise the different epistemological views of learning, relevant adult learning theory, and research regarding the major types of computer-based enhancement of classroom teaching. We then describe briefly our experiences developing SCM business simulations and how this gave us the impetus to focus instead on small-scale interactive learning modules and multimedia, collectively known as learning objects. Next we report on our experiences and feedback from students. Finally we discuss the implications of our work and future research directions.

2. Literature review

Baruque & Melo [20] state that there are three epistemological views of learning: behaviourism, cognitivism and constructivism. Behaviourists view learning as occurring
when a learner’s behaviour is shaped by the external environment. Educators with this view of learning have control over this environment and design a sequence of behaviours which enable students to progress toward a goal such as learning a concept. Cognitivists view learning as an internal process of change to a learner’s existing knowledge. Educators with this view of learning structure material to guide learners through the mental processes which will add the new knowledge into the learner’s existing mental models. With both views, the educator has a central role of disseminating knowledge but the epistemologies differ in the way this knowledge is assimilated by the learner.

Constructivists, by contrast, hold that there are many meanings and perspectives (not just those of the educator) and ways to structure our understanding of reality [21]. Learning is seen as occurring when individuals interact in or experience reality and construct knowledge [21, 22]. With this epistemology, instruction does not involve disseminating knowledge, but rather involves supporting learners in their construction of knowledge [23] and development of knowledge construction skills [22]; recognising the value and importance of prior knowledge [24]; and incorporating learning tasks into realistic contexts to facilitate richer mental models and multiple perspectives [21]. Constructivists do not, however, view any and all constructions by learners as valid, but instead judge a learner’s constructions in terms of the viability, workability and acceptability of actions and constructions compared to potential alternatives [23].

Baruque & Melo [20] argue that these three views of learning are not necessarily mutually exclusive. Instead, they believe suitable educational approaches will often need to vary to accommodate the orientation of learners: transforming (innovators) who assume responsibility for their learning and want learning autonomy; performing (implementers) who assume responsibility but only in areas of interest; and conforming (sustainers) who assume little responsibility for their learning, comply, want guidance and reinforcement. For example, they argue that education approaches advocated by constructivists are unlikely to be appropriate for learners with a conforming orientation, because such learners have little initiative or desire for autonomy which is required in constructivist-oriented learning contexts.

A theory of adult learning which we believe is applicable to tertiary education, and which can be applied by educators with any view of learning, is experiential learning theory. This theory emerged from the work of Kolb [25] in the 1970s [based on the work of 26, 27]. It posits that the most powerful adult learning occurs when learners have direct experience by taking action and reflecting on the outcomes [21]. While experiential and adult learning theorists have differing views on how learning occurs, they tend to agree that effective learning (especially in a workplace context) is a cyclic process. The steps of the process (not necessarily in this order) involve [see 14, 21]: reflecting on one’s experiences; abstracting or generalising from these experiences; testing the implications of the newly developed concepts in new situations; reflecting on these new concrete experiences; and learning by doing. This theory can be applied by educators regardless of their epistemological stance because the cycle could be educator or student led; the learners can assimilate or construct knowledge based on all views of learning; and educators with any epistemology could use such experiential approaches.

An experiential learning approach receiving increasing attention by researchers and SCM educators is the use of business simulations which aim to help students visualise the dynamic nature of supply chains and their information and material flows [10, 13, 14, 15, 16, 17, 18]. Such approaches to education are often employed by constructivists or those influenced by experiential learning theory. This is because the aim of many business
simulations is to provide an authentic, life-like context in which to explore, construct new knowledge and learn by doing [28]. However, we believe business simulations could equally be employed by behaviourists and cognitivists, who would vary the degree of structure and control of the simulation design based on their epistemological view.

The most common SCM business simulation is the Beer Game developed in the 1960s. It is a multiplayer role-playing game where each student is required to take the role of a firm in a supply chain and trade by exchanging paper-based business documents to experience the bullwhip effect [13]. The main issue with the original Beer Game was that it did not enable students to explore and experience the variety of SCM strategies which could be used to address the bullwhip effect. More recent versions of the Beer Game are computer- and Internet-based simulations (including multi- and single-player versions) which enable students to compare traditional supply chains with those employing eBusiness-enabled strategies such as quick response [10, 11, 14, 15, 16, 17, 18]. While these simulations tend to focus on SCM strategies and technologies, Fawcett & McCarter’s [12] version of the Beer Game aims to introduce students to the behavioural issues associated with SCM, such as the trust needed to share information. The simulations vary in complexity such as: the SCM strategies which can be explored; the amount of information sharing which can occur between supply chain partners; and the degree of structure or control exerted by the educator or the simulation software.

In the next section we report briefly on our experiences developing SCM business simulations and the challenges we faced which led us to pursue multimedia approaches.

3. Experiences using SCM business simulations

We have had approximately 14 years experience developing a web-based, multi-player SCM business simulation called Web-TRECS [14, 15, 16, 19, 29]. Students using the simulation are assigned the role of a firm and exchange EDI-based documents in order to meet fluctuating customer demand controlled by an educator, just like the Beer Game simulations described previously.

The simulation was time-consuming to develop, especially when the aim was for the simulation to support different educational objectives for multiple SCM and IS subjects. We also found that the simulation became too complex and difficult to maintain, and that this complexity meant other educators found it hard to apply to their educational context. Indeed, none of the educators who evaluated the SCM simulation decided to use it for the types of reasons we encountered ourselves!

Further difficulties were encountered because the technical infrastructure for such initiatives in our university is provided centrally. The simulation was initially developed on a Microsoft Server platform with Active Server Pages, but the centrally-supported platform changed to Unix and PHP. This meant we had to redevelop the software! This experience emphasises the problems which can occur when the institutionally-supported technology platforms change or, equally possible, become obsolete or replaced with new and better technology. Technological obsolescence is a major problem to be avoided.

One solution to this problem might be to source SCM simulations from other providers. Issues to take note of, however, include potential cost, whether the software will run in an institutional context (or whether it is accessible via the Web instead), and whether the simulation can be configured to address the educator’s specific objectives. In our experience, educators find these multi-player SCM simulations time-consuming to use,
such as allocating students to firms and monitoring students’ progress using the software. We therefore did not pursue externally sourced SCM simulation software.

These challenges gave us the impetus to consider alternative approaches to enhance our educational materials. We decided to explore the use of small-scale multimedia activities (e.g., videos and animations), as well as learning modules which have a single learning objective each and include one or more interactive games. Our motivation was similar to those reported in the education literature, which suggests that educators primarily use technology to enhance students’ learning experience [see 30, 31] and because of their interest in and enjoyment of technology [31].

The education literature refers to these small-scale educational activities as learning objects [20, 32, 33] and are receiving increasing attention by researchers. Barque & Melo [20] describe learning objects as having a single educational objective and a range of content (text, video, images, small games, etc) associated with that objective. The implication of their definition is that learning objects should be more easily incorporated into learning materials by educators when compared to SCM simulations. This is because a learning object is self-contained, single user and has a single objective. By contrast, we have seen that a simulation can be complex, multi-player and serve multiple learning objectives (e.g., introducing the bullwhip effect, exploring SCM strategies, etc). We must emphasise that we see learning objects as additional choices, not replacements for SCM business simulations and other traditional educational approaches.

However, there is no research examining the use of such multimedia or interactive learning modules (collectively called learning objects) in an SCM context. For this reason, in the next section we report on our experiences developing and using two such initiatives in our SCM subjects at both undergraduate and postgraduate level.

4. Teaching Online Business Interactively (TOBI)

4.1 Overview of TOBI

The current Teaching Online Business Interactively (TOBI) learning modules lead students through a learning objective (or concept) using a linear sequence of interactive activities, such as drag-and-drop games and forms. The interactive approach was inspired by experiential learning theory which advocates learning by doing. As examples, Figure (i) shows a drag-and-drop game and Figure (ii) shows clickable elements of a purchase order which move to boxes to introduce the concept of EDI data elements. The modules were developed using a combination of XHTML and Javascript (or dynamic XHTML).

This screen shot shows a drag-and-drop game where students drag their answer to complete the picture. A message appears telling them if they are right or wrong. Note that the learning objective of the module is also displayed at the top of the module to remind them of the concept being addressed. The language translation scenario is used as an analogy to help illustrate the concept and importance of standardised EDI messages.

Figure (i) EDI introduction module drag-and-drop game
This screen shot shows an activity where students: click on the text within a purchase order; and see the clicked text move into "buckets" (the boxes at the bottom of the screen) corresponding to the type of data (eg, dates, prices, etc). It is through this activity that the term "data elements" is clarified and communicated to the students in the context of EDI standards.

Figure (ii) EDI standards module clickable document game

4.2 Student comments on the TOBI modules

Two EDI-related modules were used as part of tutorial preparation activities in a postgraduate foundation eBusiness subject and an undergraduate second year subject on SCM. The first module provided an introduction to the concept of EDI by using language translation analogies to illustrate the importance of message standardisation. The second module provided an overview of the elements of the UN/EDIFACT standard.

Students were given the opportunity to complete an anonymous open-ended questionnaire at the end of each module to provide feedback on their perceptions of the module and the interactive games. An open-ended questionnaire was used so that we could obtain more in-depth, free-form comments while maintaining student anonymity. This approach also reflected the exploratory nature of this research.

There were 52 responses for the EDI introduction and 9 for the EDI standards modules. We are unable to determine the response rate between module users and respondents because the modules do not record details of module use (eg, how many accessed the modules, time spent on the module, etc). We suspect the response rate might be low because students might not wish to complete a questionnaire after spending time doing the module. But the objective of this exploratory project was primarily to gain indicative insight into students' perceptions, and to determine the value of committing to new versions of TOBI which might include usage tracking, pre- and post-test comparisons and other initiatives as part of future research.

Only 5 respondents felt that using the modules was not worthwhile. One preferred printed versions so they could take notes and go through the module on the train, which highlights the need for multiple delivery formats. The other four students stated the modules were not worthwhile because they already had knowledge of the concepts from textbooks or industry experience. In the case of the latter, it is worth noting that other students with prior knowledge still found the modules useful because they served as a refresher or, as one student commented: "They reinforce what you think you know".

Many students commented that the modules and the interactivities enhanced or improved their learning of the concepts, with typical statements shown in Figure (iii):

"I believe such learning module has helped me to understand better how EDI works because of the specific details that have been covered (especially with the help of the pictures and drag-and-drop games)."

"Actually been to these model for few times but just didn't do the questionnaire and learned lots of new things for the first time as was confuse about EDI but after that view it is just for revision"

"It does help a lot as with the graphics and flashes is more attractive and I found it easier to understand compare to the theory based text..."
"If you do some exercise you can not just skip things which you consider to have understood. You really have to think about the topic and so discover understanding problems."

"It motivate students to answer the question and make it easier to remember and understand."

"Useful because it tests my understanding of the topic being discussed."

"Forces understanding, not just reading, of the material."

"They reinforce what you think you know."

"It's useful because it tests my understanding of the topic being discussed."

"As with the games, I felt I'm involve learning the concept and found out that that's fun for doing so."

The quotes in Figure (iii) provide indicative support for our conclusion that students believe that the interactive modules helped them to understand the SCM concepts. This was further supported by the following student comments in Figure (iv) which suggest that the modules encouraged them to think, not just "gloss over" textbook readings. We note that future research is needed to determine if new learning actually occurred.

"It's useful, at least let me try to solve the problem first then come up the correct answer and explain to me why my answer maybe wrong or correct."

"It would be great if all our learning was like this."

"This is awesome, learning become more fun and interesting as it engages me to drag and drop the correct answer to correct box."

"I always enjoy interactive website like this. It's easy and fun to learn this way."

"Interactive learning is more interesting, once you go over the module, you will remember without forcing to memorize."

The positive feedback from the majority of respondents gives us confidence to undertake further work in this area. The indeterminable response rate, however, means that our conclusion is tentative and that future research is needed to generate additional data about module usage to investigate the non-response bias.

In the next section we report on our experiences using alternative multimedia resources.

5. Multimedia learning materials – CD-ROM study guide

5.1 Overview of the CD-ROM study guide

CD-ROM study materials are made available to students undertaking an introductory postgraduate SCM subject which was different to the two subjects in which TOBI was used. The materials adopt an alternative delivery format of the traditional paper-based "Study Guide" which provides a roadmap through textbook and other readings. The CD-ROM delivery method allowed for the inclusion of multimedia resources to enhance the static reading material, including audio tracks, video clips, animations with synchronised...
voice-overs and links to library readings and web resources. Students are also provided with reflection exercises and revision questions on the CD-ROM. Screen captures, highlighting some of these features, are presented as Figures (iii) and (iv) below.

This screen shot shows the use of a video clip (often obtained from industry associations such as Meat and Livestock Association) which helps students to learn the study material in context. The video clip is often used in the two-hour long lecture to break it up. The video clips are also accompanied by the transcript of the audio allowing accessibility of the explanations in text format and to cater those with disabilities.

Figure (iii) CR-ROM video

This screen shot shows the use of a flash animation to explain the concepts of supply chain management such as the Just in Time (JIT) approach. The animation is accompanied by a voice-over. The animations help students to understand the concept in a step-by-step approach. This animation can be played repeatedly as required. The animation is also accompanied by the transcript of the audio allowing accessibility of the explanations in text format and to cater those with disabilities.

Figure (iv) CR-ROM - animation

Apart from the CD-ROM, we also use an online learning management system called WebCT Vista for regular communication with the students and for the delivery of the major assignment. The assignment also contains multimedia materials, in particular the use of streaming audio and video, and Flash animations to produce a rich selection of materials to support students’ analysis of a “real world” scenario in the assignment.

5.2 Student perceptions of the CD-ROM study guide

We have received many positive comments from the students regarding their experience with the subject and in particular the use of multimedia CD-ROM study guide. While the students’ feedback is not part of this research project at this stage, the anecdotal feedback from students suggests that they found the interactive CD-ROM materials to be:

- enjoyable and even fun; better than textbooks, which they view as having large amounts of boring text;
- well structured and “uncrowded” with information which helped them to progress more effectively through the learning material; and
- relevant and interesting (especially the videos and interviews of industry experts).
Students also appeared to enjoy the major assignment, which involved them listening to online interviews with case study participants and then asking these participants questions to gain more information. The participants were the CEO and operations manager of the case company, and the owner of one of the case company’s suppliers. All three were simulated by the subject facilitator, who replied to students’ questions in the online learning environment in the character of each participant. The students found this approach to be more realistic because of the interaction with “clients” and the need for them to solve real-life business problems using the SCM concepts they had learned.

6. Reflections, implications and future research

We believe that these existing, and future, SCM learning objects have wide potential use. For example, the TOBI modules and the multimedia components described previously are being used in three subjects covering SCM technologies and concepts: two at postgraduate level and one at undergraduate level. Further, we have found that the simple, single-objective nature of the learning objects means they can be incorporated into our educational programmes in different ways. For example, educators with different epistemological views can use the objects:

- as resources accessed by students in authentic constructivist-style problem-based learning as they explore SCM solutions to the organisation issues they discover;
- as highly structured computer-based learning tools for behaviourists who want to ensure that students receive step-by-step instruction using the interactive modules;
- as activities incorporated into self-paced but structured CD-ROM study materials, as we have illustrated previously.

More importantly, we believe that these learning objects should not be seen as replacements for existing educational strategies and approaches, but rather enhancements or additional resources. In the education literature this is typically referred to as blended learning [28, 34, 35, 36] because these objects do not replace learner-facilitator or learner-learner interactions but are instead blended with other approaches. For this reason, it is not our intention to compare traditional and technology-enhanced SCM education, or compare different technological approaches. Rather it is a matter of seeing exemplars and novel approaches (such as the ones we have reported) and using what is appropriate for the specific learning objectives an educator wants to achieve.

While our anecdotal, indicative findings suggest that students do appreciate the enhancements to their learning materials using technology, we concede that this effort takes time. Indeed, education research has found that lack of time is the most significant barrier to technology use by educators [30, 31, 37]. Eynon [31] found that this was often because school/department level management tend to be more concerned that staff teach their assigned contact hours and do not allocate additional time to develop technology enhanced learning materials. Further, he found that at the institutional level there were no promotion opportunities resulting from this work. But we believe that the learning object approach has considerable potential because they are likely to be reusable – especially if SCM educators can pool their resources rather than re-invent existing efforts.

A further challenge is the skill level of educators in using software to produce the learning objects, although Neo & Neo [38] argue that this can be addressed with training in the use of software products such as Macromedia Authorware. However, even we find products such as Authorware difficult to use for producing learning modules, and we are more advanced users of software when compared to typical educators in other disciplines.
who might only have basic word processing skills. Some researchers such as Chiu & Yu [39] are trying to address this problem through the design of lightweight authoring tools, which enable educators to develop interactive learning games using common software products like Microsoft Office and without programming knowledge.

Another issue of concern with learning objects is ensuring that the learning content is not embedded in a specific delivery technology. The lessons we learned with simulations (see section 3) shows that we cannot assume that a technology will always be available. Even if a technology does not become obsolete, better technologies could emerge which we might want to use instead. Further, we experienced problems where the original developer of the Flash multimedia left the university and the source Flash files could no longer be located for updating! Lastly, feedback from our students on the TOBI learning modules suggests they would like alternative delivery formats (eg, print, online), which means that it would be better to separate the content and the delivery technology. It is therefore unwise to develop any learning material in which the content is embedded in a specific technology. This is why we do not use products such as Authorware, because it outputs content in a proprietary technology.

Stelovsky [40] takes a different approach and has developed a Java-based “shell” which can take any educational gaming content specified in XML. XML is basically a text-based specification of content which can be input by any delivery technology which supports XML. This means that the content only needs to be developed once, and it can be delivered by a range of technologies and in a range of formats. Also, if a technology becomes obsolete it can be replaced by another. Other potential advantages are that SCM educators can share XML content more easily, deliver it using a technology which they prefer or suits their learners, and adapt the content if necessary to their needs.

The main issue with the XML-based approach is that most educators would be unable to write their content in this way, because it involves using mark-up tags. Commercial products are now emerging which provide educators with a user-friendly interface for developing XML-based interactive activities. But the disadvantage of these commercial solutions is that they cost around $1,000 AUD for a single user license fee, which suggests that institutional wide roll-outs for every educator would be costly and, consequently, unlikely. In addition, the XML in these commercial products tends to be embedded in internal databases rather than being extractable or usable for other purposes.

There appears to be little research examining potential solutions to the issues raised in this paper, so this will form the basis of our future research which will involve:

- exploring if XML-based content can be used to deliver different types of interactive content in various delivery formats, including for students with disabilities;
- incorporating anonymous user tracking in the TOBI learning modules so that we can gain better insight into student engagement with the modules (and response rates);
- investigating user-friendly ways in which educators can produce XML-based learning content without having to know XML or any programming.

7. Conclusions

This paper has made valuable theoretical and practical contributions by adding to the limited research concerning the use of multimedia and interactive learning approaches in the SCM literature. It has also shown how learning theory and epistemology can be applied to SCM education. The paper has also provided indicative support for our
conclusion that interactive, multimedia learning objects have considerable potential to enhance SCM education because they:

- are easier to create when compared to complex SCM business simulations;
- can be deployed easier in different subject contexts because of their greater degree of reusability and little need for configuring, etc.; and
- have the potential to be used by educators with different epistemological views.

The primary challenge to be faced (which will be the subject of future research) is to determine effective ways in which multimedia resources can be developed quickly and easily, while also ensuring learning content is separate from the delivery technology.

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