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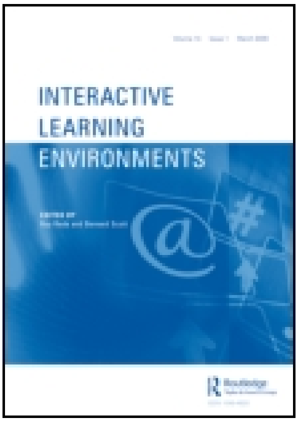

Interactive Learning Environments
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/nile20

Examining the effects of learning motivation and of course design in an instructional simulation game

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Published online: 19 Jan 2009.

To cite this article: Y. C. Chang , H. Y. Peng & H. C. Chao (2010) Examining the effects of learning motivation and of course design in an instructional simulation game, Interactive Learning Environments, 18:4, 319-339, DOI: 10.1080/10494820802574270

To link to this article: http://dx.doi.org/10.1080/10494820802574270

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Interactive Learning Environments
Vol. 18, No. 4, December 2010, 319–339

Examining the effects of learning motivation and of course design in an instructional simulation game

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(*Received 13 August 2007; final version received 1 August 2008*)

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In recent years, games have been proven to be an effective tool in supplementing traditional teaching methods. Through game playing, students can strengthen their cognitive-recognition architecture and can gain satisfaction as well as a sense of achievement. This study presents a conceptual framework for examining various effective strategies by which instructors can both integrate games into courses and strengthen games' positive influence on students' learning motivations. We used a flexible web-based instructional game called the Simulation of Production and Logistics Environment (SIMPLE) game in three decision-science courses in industrial engineering. Through this use, we evaluated the perceptions and the learning motivation attributable to a group of students after they played the SIMPLE game. We also explored the relationships between the course design and the students' learning motivations. We collected data from 139 students in the three courses and analysed the materials by using descriptive statistics, an independent *t*-test, a multiple regression analysis, one-way analysis of variance and Pearson correlation. Results showed that instructors' teaching strategies enhanced students' motivation to play the SIMPLE game and that students' learning motivation affected the students' acceptance of the SIMPLE game. The results also showed a clear and strong relationship between students' background and students' acceptance of the SIMPLE game in these three courses. By combining appropriate approaches to adopting the SIMPLE game and appropriate approaches to teaching students about production and logistics decision-making situations, instructors can create an effective learning environment for peer interaction, for learning motivation and for course-directed learning interest.

Keywords: instructional game; learning motivation; course design; evaluation study; industrial engineering

Introduction

In the fields of industrial engineering (IE) and industrial management, instructors help students develop decision-making skills for complex, ill-defined practical situations. Students, themselves, find that the use of theoretical knowledge to resolve ill-defined problems often creates more problems than it resolves. One of the reasons for the inability of traditional teaching methods to support the transformation of theory into practice is the lack of contextualised or anchored content.

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ISSN 1049-4820 print/ISSN 1744-5191 online
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DOI: 10.1080/10494820802574270
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Properly designed instructional games may viably address these needs. A telling example is the Massachusetts Institute of Technology (MIT) Beer game (http://beergame.mit.edu/), which the MIT originally developed in the 1960s. The purpose of the MIT Beer game is to show how the patterns that we create in production chains, logistics chains and customer chains sometimes yield unexpected and undesired results. After the MIT Beer game, other games emerged as part of instruction in the IE-related field. One such game is the Littlefield Technologies Game (http://littlefield.responsive.net), which two graduate students at Stanford University developed and which enables each player to act as a manufacturer that makes decisions related to queuing theory, scheduling approaches and principles of inventory management to win over other players in the game. In regard to instructional games like these, most studies focus not on the games' empirically verifiable effectiveness, but on game-design issues. Moreover, only a few studies have attempted either to integrate effective pedagogical strategies into learning or to fully utilise games' interactive features. The research community would benefit greatly from more empirical studies that examine the effectiveness of instructional games and from more empirical studies that offer guidelines for the successful implementation of games in teaching.

The purpose of this study is to investigate the effects that the Simulation of Production and Logistics Environment (SIMPLE) game has on learning motivations in different course designs. The SIMPLE game is the brainchild of the Supply-chain-management Lab at National Chiao Tung University in Taiwan (Chang et al., 2007). It is a flexible, web-based game platform that simulates various production-related scenarios to allow students to experience the consequences of their decisions made during the game. Instructors can easily adjust the game's parameters to quickly construct different decision-making situations when adopting the SIMPLE game in teaching. Thus, this study (1) describes different strategies for the integration of the SIMPLE game into three decision-science courses (production and operation management (POM), supply-chain management (SCM) and introduction to IE); (2) evaluates the perceptions and the learning motivations attributable to a group of students after playing the SIMPLE game; and (3) explores the relationships between the course design and the students' learning motivations. The results will contribute to the literature on the use of instructional games in the fields of IE and industrial management.

Literature review

Learning motivation and effective learning environments

For the past two decades, many studies have focussed on topics such as the learning behaviour and the learning motivations of university students (Dart, 1994; Paulsen & Gentry, 1995; Piccoli, Ahmad, & Ives, 2001; Pintrich, Smith, Garcia, & McKeachie, 1993; Schiefele, 1991; Zimmerman & Martinz-Pons, 1990). Pintrich and Schunk (1996) studied the relationships between students' internal motivations and learning environments. They argued that instructors are the key not only to successful supportive learning environments but also to students' effective learning motivations. Bandura (1986) proposed a social cognitive theory and, on this basis, emphasised the relationships among learning, personal faith, personal behaviour and environmental influences. Other researchers have studied self-regulated learning and have concluded that learning, being more than a connection process between new knowledge and old knowledge, is an effect of instructor-created learning environments (Pintrich & Schunk, 1996; Tuckman, 1992).

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Some researchers proposed approaches to enhance learning motivations that can surface during the learning process. Their underlying assumption was that instructors should create both cooperative and competitive relationships among students (Johnson & Johnson, 1987; Wiegmann, 1992). Following this line of study, some researchers carried out experiments on different models that addressed cooperative learning and teaching. They found that, in general, cooperative learning, indeed, has positive effects on recognition, psychology and socialisation (Johnson & De Felix, 1993; O'Donnell et al., 1985; O'Donnell, Dansereau, Hall, 1987; Slavin, 1983, 1995; Wiegmann, 1992).

Slavin (1995) argued that peer learning was a system in which students could share ideas with one another, enhance their individual learning interest and achieve goals together. Trust was critical to the cooperative-learning process. In addition, this process depended on discussion, sharing and assistance – all of which eventually enhanced the participating members in terms of their recognition capability, their emotions and their socialisation (Johnson & Johnson, 1978, 1987).

Based on the above reviews, this study concluded that, in order to enhance students' learning motivation, cognitive growth and social growth, instructors should create a cooperative and competitive learning environment. The following section deals with the strategies for instructors' creation of this type of learning environment.

The game-based teaching strategy

Recently, in addition to traditional teaching strategies, alternatives have drawn the attention of instructors and researchers (Garris, Ahlers, & Driskell, 2002; Martocchio & Webster, 1992; Mayer, Mautone, & Prothero, 2002; Petranek, Corey, & Black, 1992). Among many available strategies, gaming has been proven to be a tool that effectively enhances teaching and learning. For example, Randel, Morris, Wetzel and Whitehill (1992) stated that games that had curiosity-causing and challenging characteristics could have positive effects on learning, such as increasing students' internalisation of classroom knowledge. Because games are challenging, instructors can engage their students in either competitive or cooperative ways (Dempsey, Lucassen, Haynes, & Casey, 1996; Malone, 1981). Meanwhile, by participating in game-based role-playing, students can simulate social activity and can exercise their imaginations (Gaillois, 2001). Moreover, students can strengthen different cognitive structures (e.g. logical reasoning, hand-eye coordination) and can gain satisfaction by repeatedly playing games and by repeatedly improving the game-playing outcomes. In a similar vein, Johnson and De Felix (1993) proposed that games were pleasant and had a positive meaning to the game players. Besides those appealing characteristics, researchers believed that games, by offering game players opportunities to interact, to challenge nature and to learn competitively, could also trigger learning motivation (Mayer, Mautone, & Prothero, 2002; Rieber, 1996). Considering the benefits of game-based strategy, several studies (Hemmasi & Graf, 1992; Mayer, Mautone, & Prothero, 2002; Rieber, 1996) have confirmed that instructors approve of game-based teaching as a supplement to traditional teaching methods.

In summary, instructors can build a pleasant environment through games, whereas students can achieve a sense of victory through games; therefore, changes, challenges and fun can characterise the entire learning process, and this is the main reason for games' appeal to students.

Proven strategies for the integration of games into curriculum

The above learning outcomes did not occur simply because instructors exposed students to games, nor because students used games individually. Considering the contexts in which students develop decision-making skills for complex and ill-defined practical situations, we propose that instructors and researchers should take into consideration both the pedagogical support and the well-designed learning strategies that facilitate the integration of games into teaching practices. Figure 1 depicts the relationships that underlie supportive pedagogies (integrated well-designed games) and, in particular, the pedagogy's enhancement of learning, of curriculum and of teaching practices.

Also, from the above literature, we identified four specific principles that the curricula should contain:

(1) Challenges (Principle 1): The contents of the game need to be challenging in order to arouse students' curiosity.
(2) Competition (Principle 2): So that students' motivation remains high, either individual students or groups need to compete with each other.
(3) Cooperation (Principle 3): The design of the game should help students to develop a sense of 'work as a team and win as a team'.
(4) Authentic tasks (Principle 4): The game should incorporate authentic, real-world cases, instead of textbook-like materials.

The above discussion provides a conceptual framework for understanding effective teaching strategies by which instructors can both integrate games into courses and strengthen instructors' positive influence on students' learning motivations. This study attempts to go beyond the simple comparison between courses that use instructional games and courses that do not – a comparison that some studies have undertaken (Mayer, Mautone, & Prothero, 2002). Instead, this study manages to examine different teaching strategies and their effects on students' learning motivations. It can be seen from the above descriptions that instructors can use different strategies to establish a perfect learning environment for the students; therefore, in the supportive pedagogies, not only the content, but also the learning process need to be emphasised. This is because students can only generate understanding through interaction with the environment. Specifically, the research questions of this study are as follows:

(1) How do students perceive the usefulness of the SIMPLE game across the three decision-science courses?
(2) What are the relationships among students' backgrounds, students' learning motivations and students' acceptance of the SIMPLE game?

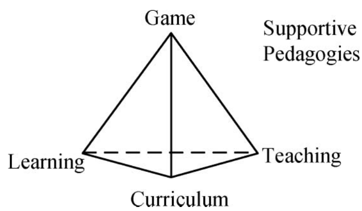

Figure 1. The conceptual structure of integrating a game into curriculum through supportive pedagogies.

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Descriptions of the game and the course design

The SIMPLE game

The SIMPLE game is a web-based instructional game that simulates various scenarios characteristic of production and logistics decision-making situations (Chang et al., 2007). The game can serve as a teaching aid to increase the instructional effectiveness in production, logistics and supply chain management and other related courses in the field of IE. This system is accessible through a web page: http://scmlab.nctu.edu.tw:8084/Esimplex (as shown in Figure 2).

The SIMPLE game provides two game modes: the Manufacturer Mode and the Supply Chain Mode. The 'manufacturer mode' is for a single player whereas the 'supply chain mode' is for multiple players playing interactively. In the two modes, a player can act as a decision maker who orders materials from the upstream supplier and manages resources. The goal is to produce adequate units that satisfy demand generated by the downstream customers. The 'downstream customer' can be played either by another player (only in the supply chain mode) or by the system (in both modes). The game cycle is arranged into weeks. Each game consists of several cycles. During the cycles, a player's decisions incur various costs. The system automatically calculates the cumulative cost after the end of each game. The system rates a player's overall performance by calculating the cumulative costs; lower the cumulative cost reflects a better performance. In an educational context, this game grants the instructors full control over the configurations. Thus, instructors can

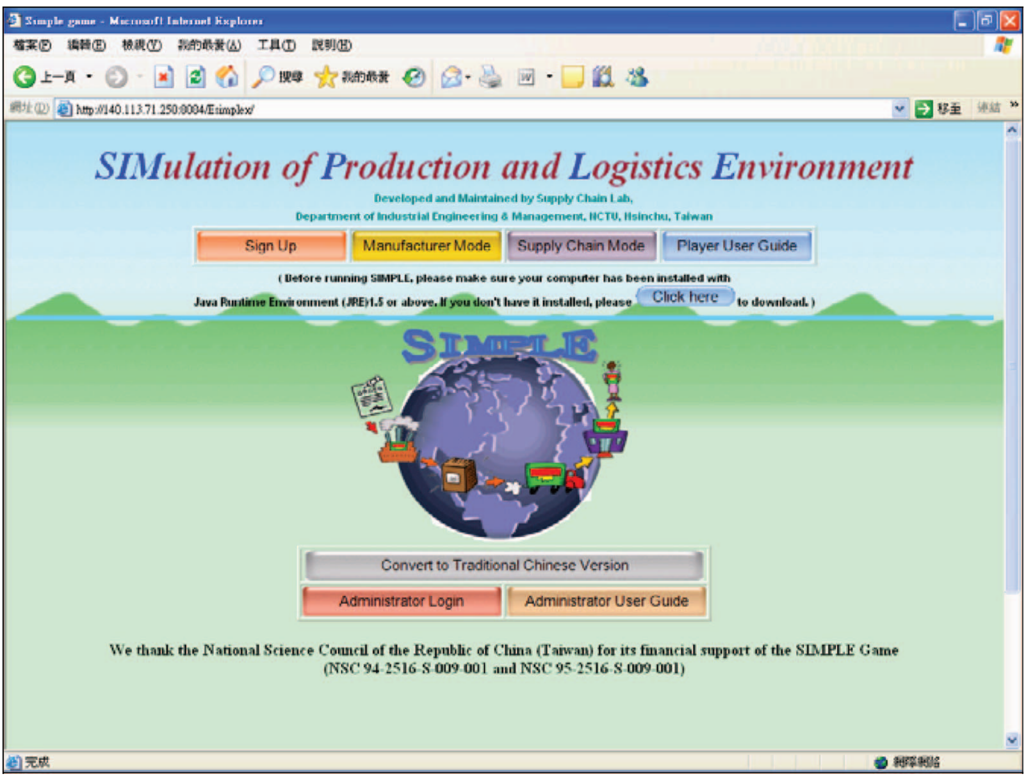

Figure 2. The homepage of the SIMPLE game.

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set the configurations according to the instructional goals at hand; for instance, the instructors can tailor the SIMPLE game to their respective course goals by setting the game's parameters regarding number of weeks and cost structure. Figure 3 describes the resources to be used and the decisions to be made by a player in the game.

Figure 4 shows a supply chain formed by four players (supplier, manufacturer, distributor and retailer) in the 'supply chain mode'. The person who acts as the game administrator can configure the number of players in the SIMPLE game in advance. The ultimate goal in a supply chain game is to minimise the total cost accumulated over

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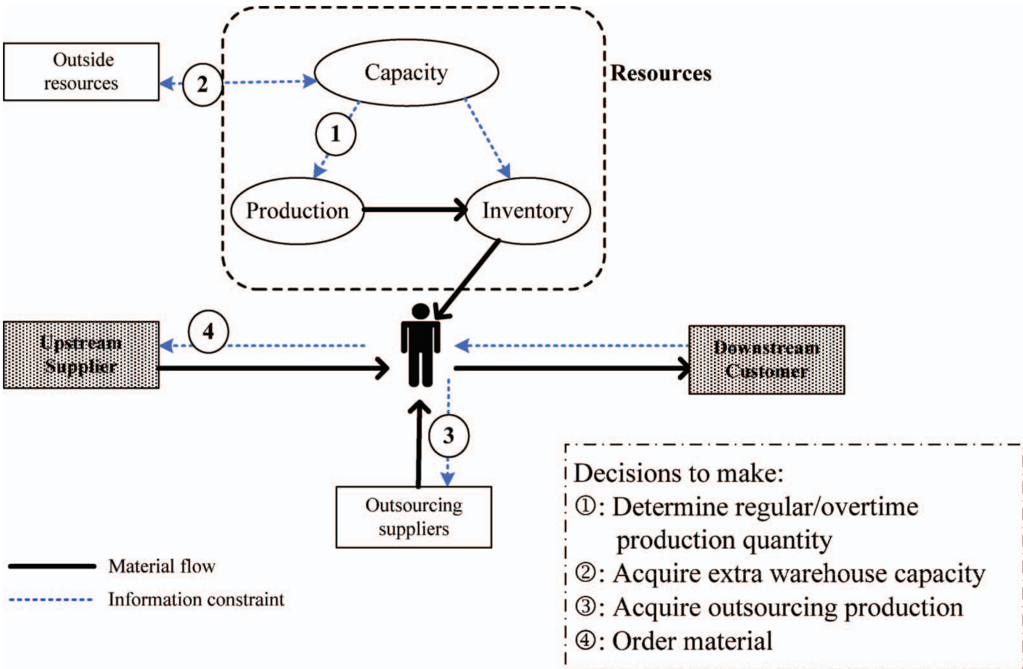

Figure 3. Player-controlled decisions and player-controlled use of resources.

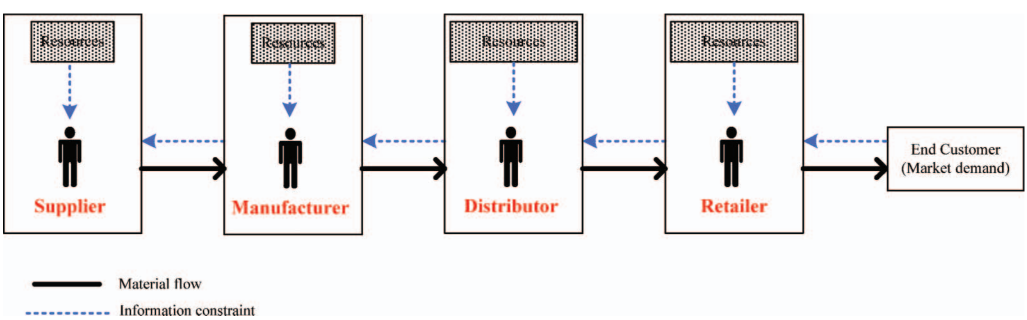

Figure 4. An example of a supply chain.

the entire chain; to achieve this goal, therefore, players have to cooperate closely with one another (this feature of the game reflects Principle 3: cooperation).

While playing a game, each player receives information from the system and uses this information to make his or her decision. The game administrator can turn on the information-sharing mechanism for multiple players so that they can discuss their strategies as well as engage in personal communications during the game. Figure 5 shows a snapshot viewed by one of the players in a four-player supply chain game. After players complete the game, the SIMPLE game displays results in summative reports and charts, on which players can check their performances (as shown in Figure 6).

The SIMPLE game represents a dynamic environment of scenarios observed in real-world business decisions (this feature of the game reflects Principle 4: Authentic tasks). In order to become successful in this game, players need to carefully meet their customers' requests by maximising the resources in a cost-effective fashion (downstream demand). In the 'supply chain mode', one player's decisions affect not only an upstream player's decisions but also the performance of the entire supply chain. Players may be able to perform well in the game if they correctly apply knowledge and use appropriate course-based quantitative techniques, such as the Model of Economic Order Quantity. Therefore, the contents of the SIMPLE game challenge both a player's knowledge and a player's skills (this feature of the game reflects Principle 1: Challenges).

Strategies for the integration of the SIMPLE game into the three decision-science courses in IE

This study has used different strategies for the integration of the SIMPLE game into the three decision-science courses. The SIMPLE game was tailored to the instructional objectives of the three courses. In the POM course and the IE course, the instructor set the SIMPLE game to the 'manufacturer mode' (single-player mode). In this mode, each

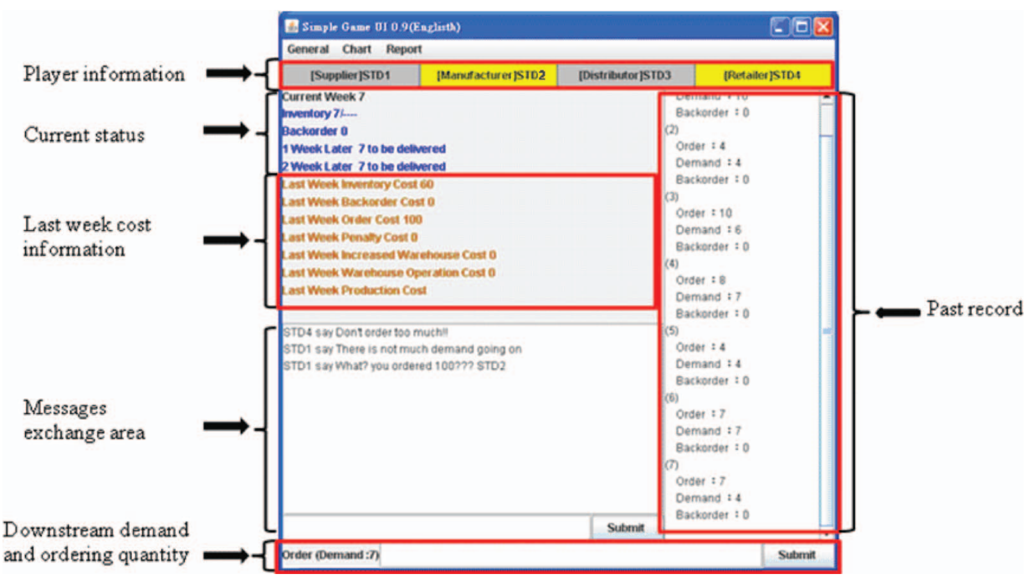

Figure 5. A player interface (viewed by one player in a four-player supply chain game).

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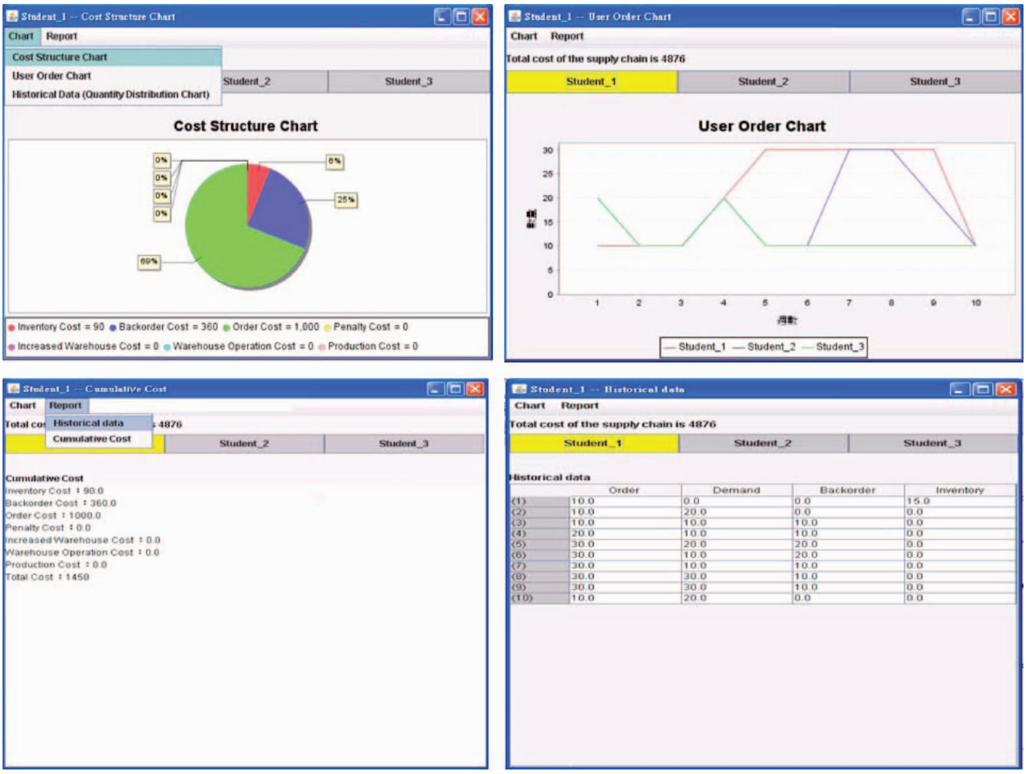

Figure 6. The results of the game (an example drawn from a three-player supply chain game).

student needed to apply the theories and the strategies related to a manufacturer's production and inventory management skills. In the SCM course, the instructor set the SIMPLE game to the 'supply chain mode' (multiple-player mode), and each supply chain had four roles (supplier, manufacturer, distributor and retailer) played, respectively, by four students. Students needed to cooperate with the members of a supply chain in order to achieve a better system-wide performance and to generate a minimum overall cost in the supply chain. In the three courses, students needed to cooperate with their team members and, simultaneously, to compete with other teams for the best performance (this feature of the game reflects Principle 2: competition). The post-game discussions encouraged students to share their game strategies and to discuss how their game strategies were related to the theories taught in the course. Upon completing the game, students submitted their reports (in groups), disclosing their game results and strategies. The instructors could, thus, evaluate the course design and the quality of students' learning by examining the total cost produced as well as the students' reports.

POM course

For the POM course, the instructor set the SIMPLE game to the 'manufacturer mode'. Every three or four students were grouped as one team, and each team played the role of a manufacturer. The game was played for 20 simulated weeks and each team was told to get

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the lowest-possible cumulative cost for the manufacturer they played. The game was played twice with a 20-min break in between to allow students discuss their game strategies. After rewarding the winning teams and hosting a post-game discussion, the instructor explained the game purpose and suggested appropriate tools and taught in class to use to excel in the game. Homework was assigned afterwards. The instructor asked each student to fill out a questionnaire before and after playing the game. Figure 7 depicts the process employed for POM course. The estimated length of time required for each stage within the process is provided.

IE course

For the IE course, the instructor also set the SIMPLE game to the 'manufacturer mode'. Every three or four students were grouped as a team and each team played as a manufacturer. The game was played for 20 simulated weeks and each team was told to get the lowest-possible cumulative cost for the manufacturer they played. Different from the process designed for the POM course, we allowed students to get familiar with the game operations before competing in class. Two weeks before the game competition, the instructor explained the game's logistics and designed a practice game for students to play online. On the competition day, the instructor re-configured the game parameters to make them different from the practice game. The game was played twice with a 20-min break in between to allow students discuss their game strategies. After rewarding the winning teams and hosting a post-game discussion, the instructor explained the game purpose and suggested appropriate tools to use to excel in the game. Homework was assigned afterwards. Each student was asked to fill out a questionnaire when the class ended. The instructor evaluated the quality of the students' learning by referring to their game costs and their homework write-ups. Figure 8 describes the design of the process employed for the IE course and Figure 9 shows a photo taken in the IE course when the game was being played.

SCM course

The aim of the SCM course is to let students understand the relationship of supply chain and to encourage cooperation. Therefore, the cooperation between all the roles in the supply chain is emphasised. Each student is encouraged to help his or her teammates

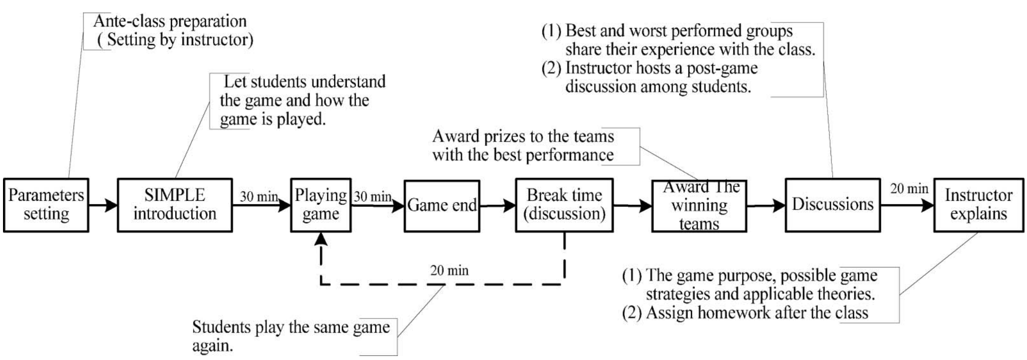

Figure 7. The design of the process employed for the POM course.

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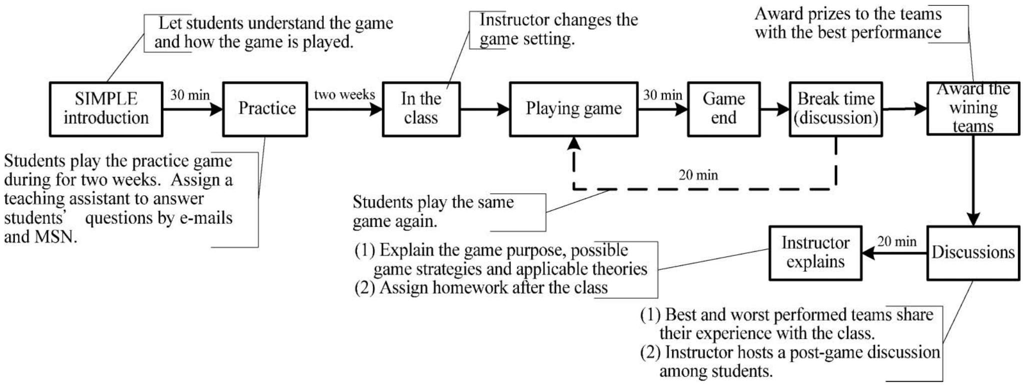

Figure 8. The design of the process employed for the IE course.

Figure 9. Students worked in groups to play the SIMPLE game (IE course).

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complete the lowest-possible cumulative cost. We adopted both the 'supply chain mode' of the SIMPLE game and the web-based MIT Beer game (http://beergame.mit.edu/) in the SCM course. The MIT Beer game is the first (and most famous) supply chain game and has been adopted by many instructors when teaching supply chain management courses to explain the bullwhip effect of the supply chain (Sterman, 1989). However, we found that the data transmission speed of the current web-based MIT Beer game was extremely slow and the game often went down (i.e. game server stopped responding) during play. Therefore, we used a 3-h class period to let students play the web-based MIT Beer game and used another 3-h class period (in the subsequent week) to let students play the SIMPLE game. Both games were played for 25 simulated weeks. The instructor asked each student to fill out a questionnaire after they had played the web-based MIT Beer game and the SIMPLE game. The design of the process employed for the SCM course is described in Figure 10.

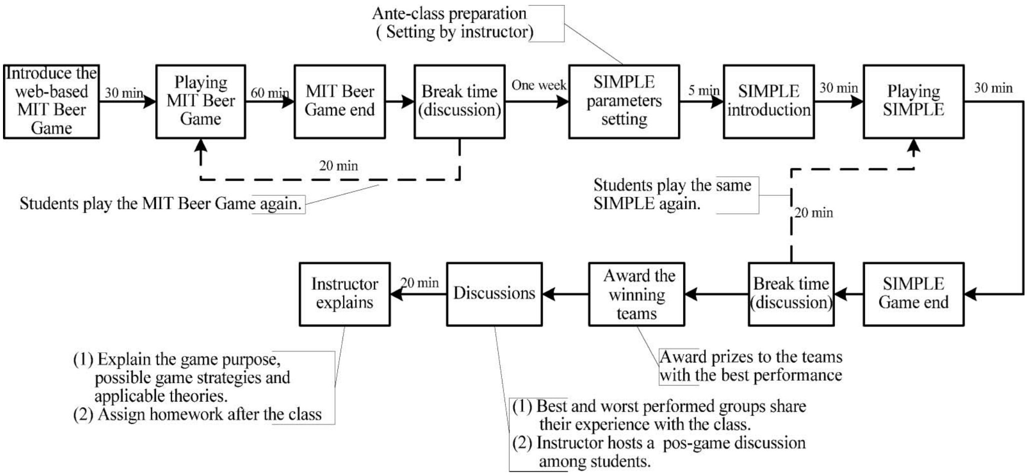

Figure 10. The design of the process employed for the SCM course.

Research methods

Participants

This study's subjects consisted of 139 students: 115 undergraduates (82.73%) and 24 graduates (17.27%). These students were enrolled in one of the three decision-science courses (i.e. POM, IE and SCM) in the Department of IE and Management at a research-oriented university in Taiwan.

Research design

This study involved a two-semester intervention period (from early September, 2006 to the end of June, 2007) during which students enrolled in one of the three decision-science courses that used the SIMPLE game as a course requirement. The study collected data from the participants by relying on a self-reporting instrument related to learning motivation. Data analysis procedures consisted of descriptive statistics, multiple regression and analysis of variance (ANOVA). These procedures underlie this study's verification of the relationships among the model's variables.

Instruments

This study used several instrument, discussed here. (1) A demographic survey: participants completed a demographic survey that included questions pertaining to their sex, academic grades, hours of weekly Internet use, major Internet activities and hours of weekly study for the course. (2) Learning-motivation survey: we selected the Motivated Strategies for Learning Questionnaire (MSLQ) to measure students' learning motivation. In particular, we used the MSLQ to investigate college students' motivational orientation and their use of different learning strategies. MSLQ is a robust instrument and consists of three parts: 'motivation' scales, 'cognitive and metacognitive strategies' scales and 'resource-management strategies' scales (Pintrich, Smith, Garcia, McKeachie, 1991). These scales can be used together or individually for the assessment of participants' learning motivation

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(Pintrich et al., 1993). Becasue the main interest of this study was students' learning motivation, the motivation scales (intrinsic and extrinsic goal orientation, task value, control beliefs about learning, self-efficacy and test anxiety) of MSLQ were selected. Moreover, we considered the adoption of the SIMPLE game as part of the teaching resources; the four variables (peer learning, time and study-environment management, effort regulation and help-seeking) of the 'resource-management strategies' scales are also selected. A total of 10 variables were selected as the independent variables. Also, we translated the English-language items into Chinese (the language that participants felt most comfortable with). This questionnaire asked participants to rate their level of agreement for each question item on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) (see Table 1 for dimensions and sample questions). (3) The game-acceptance survey: several researchers have stated that instructional tools are relevant to students' motivation (Brophy, 1988; Bruner, 1960); in this regard, we made sure that both the course content and related instructional tools were integral components of the SIMPLE game and of related teaching strategies. The participants completed a game-acceptance survey that revealed their perceptions of the SIMPLE game. In this study, we used participants' game acceptance as the dependent variable. (4) The survey on learning-interest levels (Ajzen & Fishbein, 1980; Igbaria, Guimaraes, & Davis, 1995): we used this survey to assess the learning-interest levels of the participants, because we believed that intuitive views of motivation usually strengthen interests. Therefore, learning-interest level could serve as an important aspect of motivation that causally influences learning.

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Table 1. Dimensions and sample questions from the MSLQ.

Dimension	No. of questions	Sample question
Intrinsic goal orientation	4	In a class like this, I prefer course material that really challenges me so I can learn new things
Extrinsic goal orientation	4	Getting a good grade in this class is the most satisfying thing for me right now
Task value	6	I think I will be able to use what I learn in this course in other courses
Control of learning beliefs	4	If I study in appropriate ways, then I will be able to learn the material in this course
Self-efficacy for learning and performance	8	I believe I will receive an excellent grade in this class
Test anxiety	5	When I take a test, I think about how poorly I am doing compared with other students
Time and study environment	8	I usually study in a place where I can concentrate on my course work
Effort regulation	4	I work hard to do well in this class even if I don't like what I am doing
Peer learning	3	When studying for this course, I often try to explain the material to a classmate or a friend
Help seeking	4	I ask the instructor to clarify concepts I don't understand well

Total items = 51.

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Results and data analysis

In the following sections, we discuss our data analysis and report the results in three main categories. The first section concerns our *t*-test procedure regarding the relationships among students' backgrounds, students' learning motivations and students' acceptance of the SIMPLE game. In the second section, we review this study's multiple regression analyses and report the statistical results concerning the students' learning motivations and the levels of students' learning interest in these three courses. The third section evaluates students' learning outcomes by comparing the total scores generated in the game. The mean score and the standard deviation of each dimension of the questionnaire obtained from participants in the SCM, POM and IE courses are presented in Appendix (Tables A1–A3).

Demographic description of the participants

In the three different courses, we asked participants to provide personal information including their sex, age, major, grade level, time spent on the Internet and time spent studying for the course. In order to understand the relationship between participants' demographic attributes and their acceptance of the SIMPLE game, this study performed a series of *t*-tests, ANOVA and subsequent comparisons. These results are summarised in Table 2. It can be seen from Table 2 that, for the students in the POM course, game acceptance was a function of hours spent on the Internet and of students' grades in the course; in the SCM course, game acceptance was a function of time spent in studying for this course and the students' academic grade; however, in the IE course, game acceptance was only a function of the hours spent on the Internet. The post-class interview reveals a noteworthy point regarding the SCM course: because all enrolled students were graduate students and because some of them held jobs, these students usually spent less time on the Internet. Therefore, the time spent on the Internet had a minor effect on their acceptance of the games.

Relationships among learning motivation, participants' game acceptance and the level of course-related interest

We conducted multiple regression tests to estimate the strength attributable to learning-motivation factors that may affect the students' game acceptance in these three courses. Using the stepwise regression procedure, the current study entered 11 learning-motivation factors into the regression analysis.

Table 2. The relationships among hours spent on the Internet, time spent in studying for the corresponding course, participants' grade and their acceptance of the game.

	Time spent on the Internet		Time spent in studying for this course		Students' grade	
Course	*t*	*p*-Value	*t*	*p*-Value	*t*	*p*-Value
POM	−0.132	0.048**	−0.006	0.925	0.169	0.011**
SCM	−0.063	0.418	0.262	0.001***	0.265	0.001***
IIE	−0.125	0.044**	−0.267	0.180	0.431	0.292

**$p < 0.05$, ***$p < 0.01$.

In the POM course, as shown in Table 3, the task value had a positive and significant effect on students' acceptance of the SIMPLE game ($R^2 = 0.485$). In addition, from Table 4, the degree of students' acceptance of the SIMPLE game had a positive effect on students' interest in the course ($R^2 = 0.284$). Among the 10 variables of learning motivation, only one variable (task value) entered the final regression model as a predictor of students' learning interest in the POM course.

In the SCM course, as shown in Table 5, only peer learning had a positive and significant effect on students' acceptance of the SIMPLE game ($R^2 = 0.235$). Table 6 shows that, in addition, the degree of students' acceptance of the SIMPLE game had a positive effect on students' interest in the course ($R^2 = 0.188$). That is, among the 10 variables of learning motivation, only one variable (peer learning) entered the final regression model as a predictor of students' learning interest in the SCM course. Because in the 'supply chain mode', a group of students role-plays one of the key characters in a supply chain (i.e. supplier, manufacturer, distributor and retailer), each key character in a group must closely cooperate with every other character in that group to reduce the overall cost of the supply chain. Therefore, the different approaches to integrating the SIMPLE game may result in different learning-motivation levels.

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Table 3. Summary of regression analysis for learning motivation predicting students' game acceptance (POM course).

Variable	Game acceptance		
	β	t	p-value
		3.440	0.001
Intrinsic goal orientation	0.044	0.365	0.716
Extrinsic goal orientation	−0.087	−0.788	0.433
Task value	0.236	2.244	0.027**
Control of learning beliefs	0.089	0.782	0.436
Self-efficacy for learning and performance	−0.076	−0.602	0.549
Test anxiety	0.164	1.510	0.135
Time and study environment	0.067	0.527	0.600
Effort regulation	0.027	0.242	0.809
Peer learning	−0.139	−1.015	0.313
Help seeking	0.068	0.524	0.602
R^2		0.485	

**$p < 0.05$.

Table 4. Summary of regression analysis concerning the relationship between game acceptance and students' learning interest in the course (POM course).

Variable	The degree of the SIMPLE game in triggering learning interests		
	β	t	p
		11.519	0.000
Acceptance of the SIMPLE game	0.284	4.419	0.000***
R^2		0.284	

***$p < 0.01$.

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Table 5. Summary of learning-motivation regression analysis regarding predictions of students' game acceptance (SCM course).

Variable	Game acceptance		
	β	*t*	*p*-Value
		2.756	0.008
Intrinsic goal orientation	−0.036	−0.250	0.804
Extrinsic goal orientation	−0.054	−0.433	0.667
Task value	0.121	0.885	0.380
Control of learning beliefs	0.120	0.974	0.347
Self-efficacy for learning and performance	−0.148	−0.981	0.331
Test anxiety	0.038	0.303	0.763
Time and study environment	0.139	0.982	0.330
Effort regulation	−0.027	−0.221	0.826
Peer learning	0.329	2.522	0.014**
Help seeking	0.199	1.568	0.122
R^2		0.235	

**$p < 0.05$.

Table 6. Summary of regression analysis concerning the relationship between game acceptance and students' learning interest in the course (SCM course).

Variable	The degree of the SIMPLE game's triggering of interests		
	β	*t*	*p*
		8.515	0.000
Game acceptance	0.188	2.463	0.015**
R^2		0.188	

**$p < 0.05$.

Two weeks before the integration of the SIMPLE game into the IE course, the instructor engaged the students to work in teams, using the 'manufacturer mode', which was originally designed for an individual-learning situation. Meanwhile, two important steps took place: the instructor allowed students to access the game's content and assigned one teaching assistant to guide students' Internet-based group discussions; these two steps mean that students had more time to collaboratively work on the project outside the class. The results of the regression analysis confirm that task value and peer learning had a positive and significant effect on students' acceptance of the SIMPLE game ($R^2 = 0.21$), whereas other learning-motivation variables failed to contribute to students' game acceptance (as illustrated in Table 7). Moreover, the regression analysis shows that students' game acceptance had a positive and significant effect on students' learning interests triggered by the SIMPLE game ($R^2 = 0.170$), as shown in Table 8.

Lastly, the current study performed a *t*-test to identify the mean difference between the total cost generated by students in the IE course and the best-known solution and the corresponding mean difference generated by students in the POM course. A significant difference was found ($t(8, 10) = 5.479, 9.371, p < 0.05$) insofar as the students in the IE course outperformed the students in the POM course. Table 9 shows a comparison of the total cost generated in the same 'manufacturer mode' in the POM course and the IE

Table 7. Summary of learning-motivation regression analysis regarding predictions of students' game acceptance (IIE course).

Variable	Game acceptance		
	β	t	p
		9.425	0.000
Task value	0.158	2.266	0.025**
Peer learning	0.235	3.375	0.001***
R^2		0.212	

**$p < 0.05$, ***$p < 0.01$.

Table 8. Summary of regression analysis concerning the relationship between game acceptance and students' learning interest in the course (IIE course).

Variable	The degree of the SIMPLE game's triggering of interests		
	β	t	p
		18.056	0.00
Game acceptance	0.086	2.004	0.046**
R^2		0.170	

**$p < 0.05$.

Table 9. A comparison of the total cost generated in the same manufacturer model (the POM course and the IIE course).

Course	Minimum cost	Maximum cost	Average cost	Standard deviation	Best-known solution	The difference of the (average cost) minus the (best-known solution)
POM	1306	2370	1812	346	730	1082
IIE	1269	2333	1922	519	1064	858

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course. For students' in the IE course, the difference between their average score (1922) and the best-known solution (1064) is 858, whereas for the students' in the POM course, the difference between their average score (1812) and the best-known solution (730) is 1082. It is apparent that the average scores of the IE course's student groups were closer to the best possible scores than were the average scores of the POM course's student groups. Meanwhile, after reviewing the reports written by each group, we found that during the groups' report-writing period, students in the IE course still used the game, continued to experiment with different strategies for better game scores, and demonstrated a greater understanding of and better uses of related management theories. Regarding the POM course, however, we found that only very few students either actively used the SIMPLE game or used related theories.

We summarised the results of the above analyses in Table 10. The results show that an appropriate approach to adopting the SIMPLE game, combined with appropriate

Table 10. A summary of the significant levels found in the three courses (task value and peer learning to game acceptance).

Course	Task value	Peer learning
POM	✓	✗
SCM	✗	✓
IIE	✓	✓

teaching strategies, can create an effective learning environment for better peer interaction, for better learning motivation and for better course-directed learning interest.

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Conclusions and discussions

This section discusses, in detail, the educational implications derived from the interpretations of the study results, the limitations of the study and recommendations for future studies.

There are many simulation games (Elgood, 1997; Graham & Gray, 1969) in the business-administration and production-management fields, and these games have proven to be effective teaching aids because they enhance teaching and students' learning interest (Alessi & Trollip, 1985; Martocchio & Webster, 1992; Quinn, 1996). Some studies focus on the research and development of instructional games (Lewis & Maylor, 2007), but very few deeply and rigorously address effective strategies for the integration of games into courses. In this study, we present a conceptual framework for linking pedagogy and the SIMPLE game, whose flexible web-based learning environment helps instructors integrate industrial-management contents into their teaching practices. The results show that the two modes of the SIMPLE game (the manufacturer mode and the supply chain mode) are easily adaptable to and usable throughout the decision-science courses.

According to the post-game survey, students' learning motivation affected their acceptance of the SIMPLE game, whereas their acceptance attitudes certainly resulted in stronger course-directed learning interests. However, the levels of students' acceptance varied, owing to the students' different backgrounds (e.g. undergraduates and graduates) or to the design of the game; for example, in the POM course, all the students were undergraduates who highly valued the contents and the tasks provided by the SIMPLE game, whereas the students' high task values reflected the students' high acceptance of the game. The students desired to play the game 'one more time' in order to improve their scores – that is, in order to reduce production costs even further. However, the students mentioned that an orientation or user manual would have been beneficial, because these two supportive materials could have helped students familiarise themselves with the game settings.

In the SCM course, students' learning motivation came from peer learning: the learning tasks required that each student play the role of a character in the supply-chain process and each character needed to cooperate with every other character to reduce the production cost. It is worth noting that, in this regard, students had intense discussions with one another during the competition break time.

Taking the lessons learned from the design principles and from the above two courses, we responded to the third course, the IE, on the basis of some new strategies, such as presentation of a game orientation, promotion of group-related student activities and greater outside-class student practice time. Two weeks before the competition day, students began to use emails or instant messenger (e.g. MSN) to post questions about game strategy, and students even reported technical difficulties (such as shutdowns of the SIMPLE game server while the students wanted to practice the game). On the competition day, before the competition, during the break time and after the competition, all the students engaged in very intense interactions with their peers. In addition, students asked the instructor aggressively after the class about the SIMPLE game design and about business-administration strategy in the real world – these occurrences constitute proof of the students' interest in the SIMPLE game. In the end, these students – because they demonstrated higher task values and a more adequate sense of team-work than did the students from the other two courses – exhibited higher game acceptance and higher course-directed learning interest than did the students from the other two courses. These findings are consistent with other studies (Pivec, Dziabenko, & Schinnerl, 2003; Timo & Sami, 2006), according to which challenging games that unfold in cooperative learning environments are effective teaching aids: they raise students' learning motivation. The findings have also proved the effectiveness of the SIMPLE game.

Therefore, the integration of games into courses can be a fruitful practice; however, as the findings show, differences between a course's integration planning and another course's integration planning account for differences between the learning interest of a course's students and the learning interest of another course's students. For example, in this study, when the planning enabled students to register, login and freely practice the game, they could explore independently the decision-making characteristics of the manufacturer and the enterprises in the supply chain. The findings show, also, that a game's flexible setting enables instructors to fine tune different simulation situations. Besides competition, adequate pedagogical supports, such as encouragement, greatly help students to develop their autonomy and to retain their learning interest.

This study presents the lessons learnt during the implementation of the SIMPLE game. The study's goal is to contribute useful instructional and pedagogical guidelines to future researchers and instructors who use web-based games to enhance students' learning motivation and outcomes.

The SIMPLE game constitutes a flexible platform currently available to the public for free; hence, we believe that this website can serve as a starting point from which researchers and educators can adopt for the purposes of research and teaching in decision-science knowledge and strategies. Also, the website can be a great idea-exchanging channel where users can find different solutions to problems concerning production, logistics and SCM. Currently, the SIMPLE game has a Chinese-language mode and an English-language mode; in the future, universities in various cultures and in various nations could use the game so that researchers could more rigorously analyse the differences that arise in these multi-cultural contexts. In addition, the SIMPLE game has a database that retains information about themes such as players' online-connection times, players' weekly purchases and players' weekly inventory; therefore, in the future, researchers can further analyse students' decision-making behaviours and the relationships between students who use the game in the class and students who use the game outside of class.

Acknowledgement

This study was supported by the National Science Council (NSC) of the Republic of China (Taiwan), under grant numbers NSC-94-2516-S-009-001 and NSC-95-2516-S-009-001.

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Appendix

Table A1. Students' scores regarding the MSLQ in the POM course.

Dimension	Mean	Standard deviation
Intrinsic goal orientation	3.78	0.66
Extrinsic goal orientation	3.48	0.91
Task value	3.84	0.71
Control of learning beliefs	3.46	0.93
Self-efficacy for learning and performance	3.34	0.79
Test anxiety	3.01	0.93
Time and study environment	3.43	0.77
Effort regulation	3.73	0.87
Peer learning	3.47	0.83
Help seeking	3.37	0.94
Game acceptance	3.79	0.77
The triggering of interest by the game	3.95	0.90
The SIMPLE game user interface design	3.87	0.82

Total number of subjects: 32.

Table A2. Students' scores regarding the MSLQ in the SCM course.

Dimension	Mean	Standard deviation
Intrinsic goal orientation	3.93	0.78
Extrinsic goal orientation	3.46	0.83
Task value	4.15	0.68
Control of learning beliefs	3.12	1.06
Self-efficacy for learning and performance	3.44	0.79
Test anxiety	3.39	1.01
Time and study environment	3.65	0.93
Effort regulation	3.50	1.04
Peer learning	3.51	1.03
Help seeking	3.69	0.94
Game acceptance	4.10	0.73
The game's triggering of interest	4.00	0.95
The SIMPLE game user interface design	3.80	0.73
The web-based MIT Beer game user interface design	1.73	0.20

Total number of subjects: 24.

Table A3. Students' scores regarding the MSLQ in the IE course.

Dimension	Mean	Standard deviation
Task value	3.60	0.60
Peer learning	3.30	0.90
Game acceptance	3.80	0.60
The game's triggering of interest	3.40	0.80
The SIMPLE game user interface design	3.50	0.70

Total number of subjects: 68.