Development of a VR-Based Engipreneur Training System

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Abstract

Educating engineering entrepreneurs (engipreneurs) is important yet difficult in the 21st century. This paper describes the development of a VR-based engipreneur training system, which we call Sim Engipreneur, for young engipreneurs. The goal is to simulate the process of entrepreneurship. We use a project management approach integrating 3D Studio MAX, Photoshop and Virtools into an instructional computer game where we bring together elements of interaction, realism and high interest to model an engipreneur learning scenario. The components, decision checkpoints, and visuals created are described in detail. Because Sim Engipreneur utilizes models and simulation instead of real-world objects and operations, players are able to practice and acquire entrepreneurial skills that are relevant to their needs in a risk-free and cost-effective virtual environment. An evaluation was carried out by experienced entrepreneurs and engineering students to analyze this version of Sim Engipreneur system. Preliminary results show that the proposed Sim Engipreneur system is able to enhance young engipreneurs' learning achievement. In a future study we will carry out an in-depth analysis of the Sim Engipreneur system that will be presented in a subsequent article.
Keywords: Virtual reality, instructional computer game, entrepreneur education, computer-assisted instruction, project management

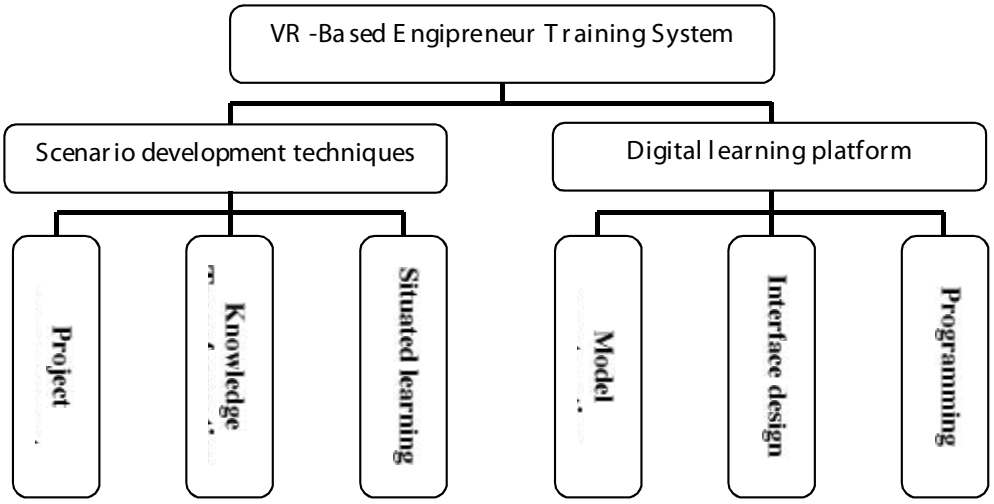
1. INTRODUCTION

In the past decade, rapidly developing countries like Taiwan and Korea, have taken advantage of their low-cost labor to establish OEM business models and secure a larger share of world markets. They have created their economic miracles by stressing standards of operation and efficiency in the manufacturing sector. However, with the rise of globalization and concomitant economic transformation, recently these countries' manufacturing industries have lost some of their competitive advantage [2]. Moreover, with the spread of the recent worldwide financial crisis, the current unemployment rate in the United States of America has reached record highs, and countries around the world are experiencing similar increases in unemployment. Hence, it is imperative to introduce innovative policies to spur new business development. Nowadays, creative education and engineering entrepreneurship (or engipreneurship) innovation are becoming key issues. That is, we are seeing a trend that emphasizes entrepreneurship education in the development of engineering and business education. With effective entrepreneurship education, young professionals are able to start their business with greater confidence. The problem of unemployment issues can also be mitigated [4]. Thus, training courses designed for entrepreneurship education are drawing a lot of attention from governments and academia [3].

With the maturation of hardware and software technologies, computer games have become increasingly sophisticated, as well as widely popular and convenient for e-generation people to use. Such games are good for not only entertainment but also education [10]. By incorporating elements of video games, a computer-aided training platform may be able to provide a way to improve conventional teaching and learning systems through creative game playing [7] [8]. It may also enhance learners' motivation for learning [11] [13]. That is, learners can play while learning and learn while playing and so circumvent some of the limitations associated with traditional learning methods [1]

[12]. They can learn anytime or anywhere. This can lead to developing a digital learning platform for learners and a virtual environment simulation of entrepreneur activities without temporal or spatial constraints [6]. It is proposed that with the assistance of digital learning systems, learners' entrepreneurial skills and knowledge can be enhanced dramatically. The purpose of this paper is to describe the development of a VR-based learning system for engipreneur training. This study consists of three parts: (1) designing an engineering entrepreneurship simulation game learning scenario using entrepreneurship activities and project management techniques [5]; (2) developing a VR-based learning system for engipreneur training; and (3) evaluating the feasibility and outcomes of the proposed engipreneur training system. The paper is organized as follows: Section 2 shows the scenario design and approaches. Section 3 introduces the development of the VR-based engipreneur training system. Section 4 presents the results and discussion of the VR-based engipreneur training system. Section 5 ends with the conclusions of this study.

Figure 1. Structure and procedures used for system development.

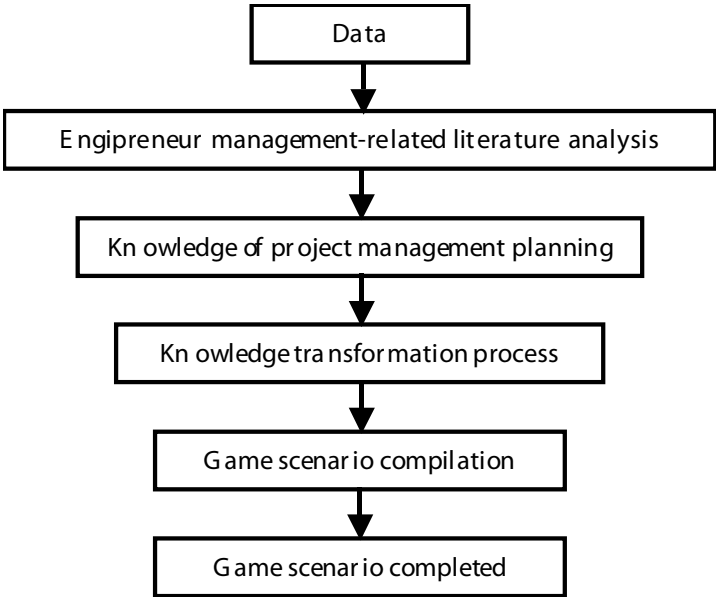


2. SCENARIO DESIGN AND APPROACHES

The core of this VR-based engipreneur training system is the scenario design. In this project, the adopted methods and techniques include: project management method, scenario development technique, Delphi technique, and knowledge transform method. That is, this proposed engipreneur training system is a scenario-based video game. Figure 1 shows the structure and procedures for system development.

This engipreneur training system video game is called "Sim Engipreneur" because it simulates the processes involved in becoming a successful enginpreneur. In Sim Engipreneur, a virtual young engineering graduate (Jack) wants to run his own creative doll design and manufacturing business. To achieve his goal, he has to complete specified tasks in order to start up his business. The simulated tasks that make up the game were identified and designed after interviewing several experienced entrepreneurs from the Innovation and Incubation Center at National Kaohsiung First University of Science and Technology (NKFUST) using the Delphi method. Next, we adopted appropriate project management methods and knowledge transformation techniques to develop an entrepreneur training simulation scenario. Figure 2 shows the scenario development process for the engipreneur training simulation. In Sim Engipreneur, the major tasks that the player must accomplish are: (1) drafting a business proposal; (2) selecting a plant location; (3) registering the company; (4) raising funds and loans; (5) purchasing equipment and tools; (6) recruiting and hiring; (7) fabricating and marketing products; (8) analyzing market crises and providing strategies to address them. These eight tasks were formed and examined in the stage of venture planning and analysis and constitute stages or checkpoints where the system can assess the player's developing entrepreneurial skills. This process of planning and analysis follows the project management method as a guide. The result is then transformed into a game scenario by using the knowledge transformation technique.

Figure 2. Scenario development process for the entrepreneurship simulation video game



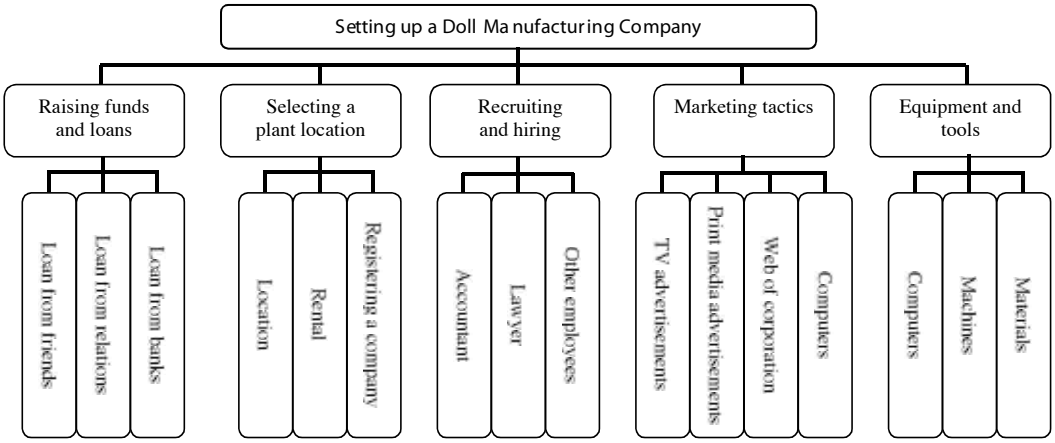
2.1 Venture Planning and Analysis

As outlined above, in order to set up a viable enterprise, an entrepreneur has to address and successfully complete the following tasks: business proposal planning, plant selection, company registration, fund raising, equipment purchasing, recruiting and hiring, and product fabrication and marketing. In this study, the project management method was adopted as a guideline for planning and analyzing the schedule, resources, capital and manpower requirements for the venture activities. The results form the basis for developing the scenario for Sim Engipreneur. The contents of entrepreneurship activity planning are as follows [9]:

(1) Work Breakdown Structure (WBS) Analysis

After the goal of the business has been defined, the next step involves analyzing the tasks of the entrepreneur activity. The work breakdown structure (WBS) method was employed in this study. The venture activities can be broken down into several sub-units in accordance with a process-oriented approach. With breakdown sub-modules, the contents for each venture activity become clear and easy to manage and follow up. Figure 3 shows the WBS for Sim Engipreneur. Tasks, such as shop selection, fund raising, recruitment, equipment purchasing, and marketing are important and challenging, especially to new entrepreneurs. Hence, acquiring experience through Sim Engipreneur is the main focus of this entrepreneur training simulation game.

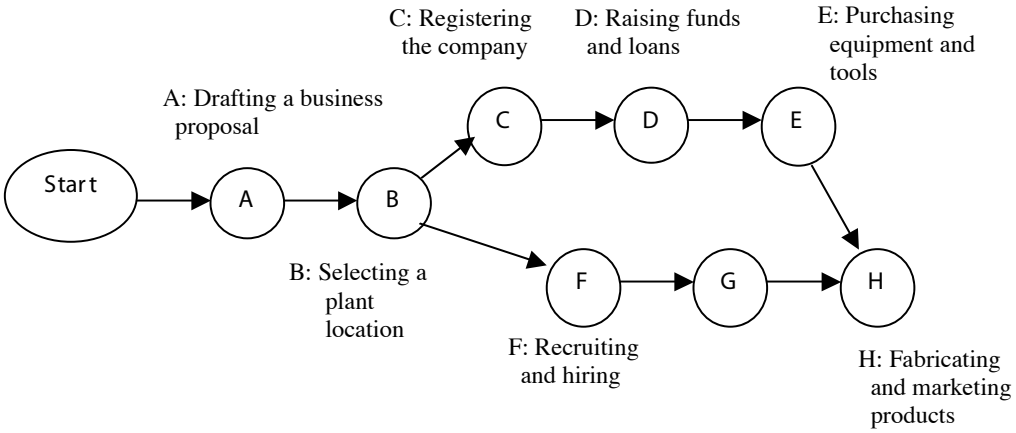
Figure 3. WBS of Sim Engipreneur.



(2) Activity Sequence

After defining the WBS for each task, the entrepreneur must carry out several jobs in a sequence and/or as parallel processes. The activity sequence of the Sim Engipreneur can be illustrated in a web net chart as seen in Figure 4. As soon as the business plan is defined and the shop location is selected, other activities can proceed in parallel. Each activity was assigned a code. The project management technique by code allows for easier project follow-up.

Figure 4. Web net chart of activity sequence for Sim Engipreneur.



(3) Schedule Management

In a business startup plan, project schedule management is essential to ensure the project remains on target and is successful. A Gantt chart is a popular tool for tracking projects. Table 1 shows the milestones for Sim Engipreneur. In this example, the case study tasks were scheduled for six months in the entrepreneur training simulation. As can be seen in Table 1, the player feels that analyzing market crises and developing strategies to deal with them, recruiting employees, and manufacturing products and marketing them are more challenging and will require more time, while he/she feels that registering the company, and raising funds and securing loans are relatively easier.

Table 1. Gantt chart of an entrepreneur training simulation.

Code	Working Items	Begin	Finish	Month
				1 2 3 4 5 6 7 8 9 10 11 12
A	Drafting a business proposal	3/03	3/17	
B	Selecting a plant location	3/18	4/01	
C	Registering a company	4/02	4/23	
D	Raising funds and loans	4/23	5/23	
E	Purchasing equipment and tools	5/23	7/23	
F	Recruiting and hiring	4/02	6/02	
G	Analyzing market crises and providing strategies	6/02	7/02	
H	Fabricating and marketing products	7/03	9/03	

(4) Budget Planning

Budget planning and management are a key challenge for a young entrepreneur and have to be carefully arranged according to the WBS and activity sequence analysis. The engipreneur player has to estimate the cost of each task and arrange a payment schedule for the first year's operation. Table 2 shows an estimation of the initial costs and the first year's operation.

Table 2. Sample budget estimation.

Code	List of activities	Cost (NT dollars)
A	Drafting a business proposal	10,000
B	Rent	600,000
C	Registering the company	10,000
D	Personnel costs	2,160,000
E	Marketing management	180,000
F	Purchasing equipment and tools	4,000,000
G	Water and electricity costs	500,000
H	Fabricating	120,000
Total	First year of venture capital	7,580,000

(5) Risk Analysis

Entrepreneurial activities are full of risks. In order to attempt to forecast the risk factors in the planning stage, the engipreneur player has to analyze the risk factors for each task well beforehand to ensure the success of his/her business. In *Sim Engipreneur*, several potential factors are introduced into the scenario in order to train young entrepreneurs to develop their risk analysis abilities and to prepare them to solve risk-related problems. Seven general risk factors and strategies for coping with them are introduced in the simulation. Table 3 shows common factors encountered and possible solutions [9].

Table 3. Risk planning.

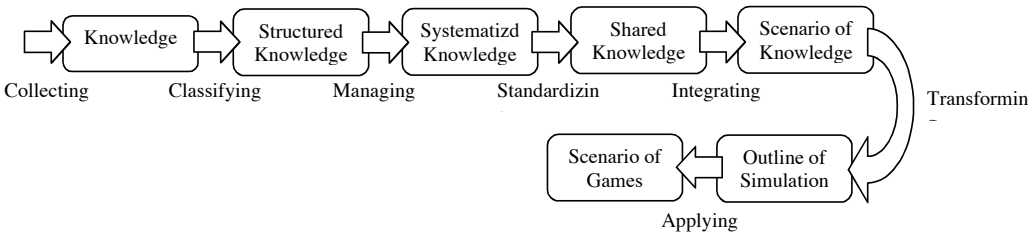
Code	Risks that may be encountered	Solutions for reducing risks
1	Insufficient funds	Reduce the startup costs
2	Selecting the wrong location	Select a new location
3	Inventory control is improper	Produce in accordance with the volume of orders
4	The policy of accounts receivable is bad	Implement cash only transactions
5	Operating costs are too high	Lower operating costs
6	Improper investment in equipment	Avoid the use of working capital investment

7	Lack of experience	Cultivate professional skills and knowledge

2.2 Scenario Design and Knowledge Transformation Method

Transforming the fundamental knowledge of and experience with entrepreneurship into the scenario for the entrepreneurship simulation game is a creative challenge. In Sim Engipreneur, we make use of the knowledge transformation method to interpret the collected knowledge and apply it in the scenario by using a process of collecting, classifying, managing, standardizing, integrating, and transforming. The process of the transformation is shown in Figure 5.

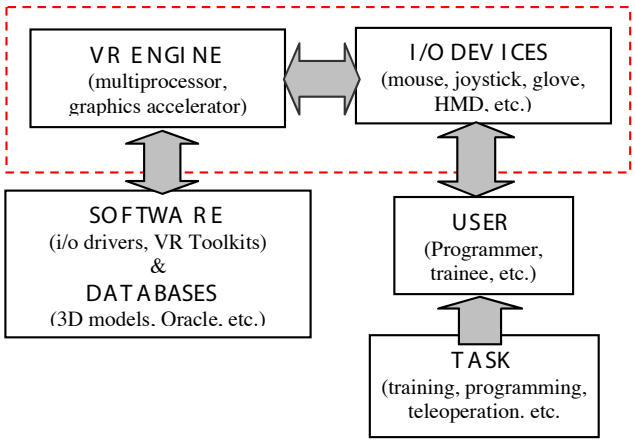
Figure 5. The process of the transformation.



3. SYSTEM DEVELOPMENT

Because the objective of *Sim Engipreneur* focuses on improving participants' entrepreneurship knowledge and giving them experience via video game playing, it simulates the process of entrepreneurship activities with a virtual environment. Working through the checkpoints, the engipreneur player can enhance his/her entrepreneurial skills. To be effective, the features of this engipreneur simulation game must include: (1) entrepreneurship knowledge and processes simulation; (2) a realistic scenario; (3) freedom to choose when making decisions; and (4) functions of assets and liabilities. Generally, VR systems consist of three parts: a VR engine, I/O devices and a Human-Machine Interface (HMI). Figure 6 shows the structure and components of a virtual reality system. In this study, our VR animation engine is programmed in Virtools; the I/O devices are mouse and keyboard; and the HMI and assessment engine are programmed in VB. The development of *Sim Engipreneur* also consists of a simulation script, virtual objects and environment construction, and VR animation editing. The VR objects and environment were constructed using Autodesk 3Ds Max modeling software and the Virtool VR animation software and will be described below.

Figure 6. Structure of a virtual reality system



3.1 Engipreneur Simulation Script

After interviewing experienced entrepreneurs at NKFUST's Innovation and Incubation Center, we developed a sce-

nario and script for Sim Engipreneur that involves an engipreneur player named Jack, who is a college undergraduate with several years of work experience in product design and manufacturing. Jack has a dream to start his own business using his expertise and working experience. His expertise is in creative product design as well as manufacturing. Having researched the field, he has decided that doll products continue to be very popular items, and the market still appears to have room for growth. Hence, he wants to set up a doll design and fabrication shop using his professional skills. With this as the background, the engipreneur activity begins. How will he make this venture a reality? Figure 4 above outlines the basic order of the steps he must take, and the following description provides details about the processes.

Jack will begin by collecting business information and writing a business plan. Meanwhile, he is looking for a suitable shop location as well as searching for information about the availability and cost of equipment and tools for fabrication. In Jack's business plan, he estimates that his starting budget must be about seven million NT dollars for the startup and to cover the costs of the first year of operation. Before implementing his plan, he needs to raise funds and register his company with the government. He is planning to get loans from family members, friends, and his bank. After Jack's finances are secured, he will recruit and hire several employees via newspaper and the Internet. However, before he can begin production he must also purchase equipment and tools and make preparations to begin manufacturing. At the same time, Jack and his staff are discussing the company's marketing strategy via the Internet, post-mail flyers, and local and international toy shows to promote his products. Jack projects that it will take three years to break even, after which he will make profits of about 50% of the capital annually.

As mentioned above, Sim Engipreneur has eight checkpoints or stages. Each stage has its own objective. The player acquires different entrepreneurial knowledge and experience at each stage. All stages are implemented in a virtual environment. The virtual city was created by using 3Ds Max and Photoshop software packages. Figure 7 shows the virtual city. The game is designed to run for 30 minutes after the player reads the scenario that gives the background information needed to play the game. In that time, the engipreneur player has to complete the eight required checkpoints and make good decisions to solve problems in order to pass each challenge as represented by the checkpoints. The results of Jack's decisions at each stage are evaluated and graded by the system. These decisions will affect the final outcome when the simulation concludes. Upon completing the simulation, Sim Engipreneur gives the player a final grade, pass or fail.

Figure 7. Virtual entrepreneur environment.

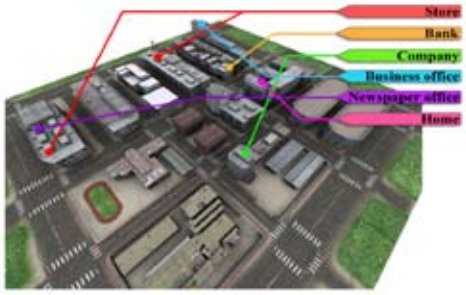
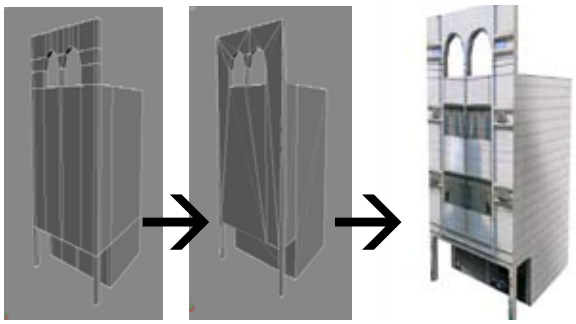


Figure 8. (a) Original model with 308 polygons; (b) polygons reduced to 126; (c) virtual building with photo image outlook



3.2 Virtual Engipreneur Simulation System (*The Sim Engipreneur*)

The development of the virtual engipreneur simulation system consists of two major components: virtual object modeling and animation editing. In modeling the virtual Sim Engipreneur, we used 3Ds Max in combination with Photoshop software. These modeling applications provide user-friendly tools for rapidly editing virtual objects using 3D CAD drawings and photo picture forming techniques. Figure 8 shows (a) a 3Ds Max created 3D model, (b) a polygon number reduced 3D model, and (c) a 3D model with real photo outlook for a virtual building. With the polygon reduction technique of 3Ds MAX, the 3D model's polygons were reduced from 308 to 126, a 244% reduction rate, which allows images to be displayed more rapidly during the course of the game. In order to increase the realistic view of images and decrease the building time of the virtual environment, we adopted a hybrid technique of 3D CAD and camera image. The outlook image of the virtual building was taken with a digital camera, and then put it onto the surface of the 3D model to quickly form the virtual object. Figure 9 shows several sample virtual buildings of the virtual city created by 3Ds Max in combination with Photoshop software. Another, more complete view of the virtual city is shown in Figure 7. After the virtual objects were modeled, the virtual models were then exported into .NMO format for later VR animation editing.

Figure 9. Virtual objects

<table>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Virtual Commercial District</td><td>Virtual Living District</td><td>Virtual School District</td></tr>
<tr><td>  </td><td colspan="2">  </td></tr>
<tr><td>Virtual Industrial District</td><td colspan="2">Virtual City</td></tr>
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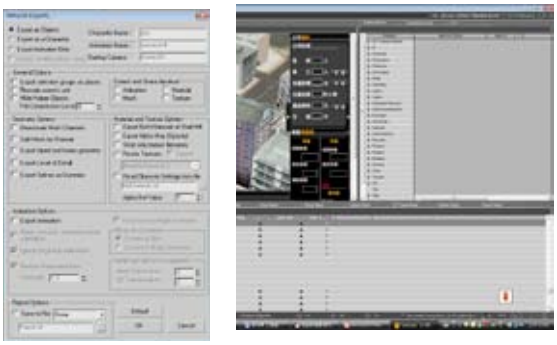
Figure 10. Virtools interface



The VR animation software used in this project was Virtools. Figure 10 shows typical Virtools programming interface windows. The interface of the simulation system (Sim Engipreneur) consists of five windows for status display and data entr. The Sim Engipreneur system interface is divided into five areas: (1) operational function selection (game function), (2) company status display (game goal), (3) financial status display (balance sheet), (4) order and fabrication data entry (company information), and (5) virtual environment illustration (game frame).
In accordance with the scenario analysis, the Sim Engipreneur system was designed in a query & answer (Q&A) format with eight major checkpoints for engipreneurship training. Each checkpoint asks the player to enter his/her decision at each stage. With the player's inputs, the result will be simulated and then displayed. All of the player's inputs along with the simulated results will be evaluated and scored at the conclusion of the engipreneurship simulation. The eight checkpoints for entrepreneurship training processes are: (1) product design, (2) venture plan and proposal, (3) shop location selection, (4) company registration, (5) financing, (6) procurements, (7) recruitment and hiring, and (8) marketing and others.

Figure 11. A sample Sim Engipreneur program

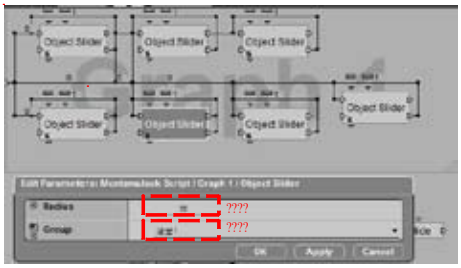
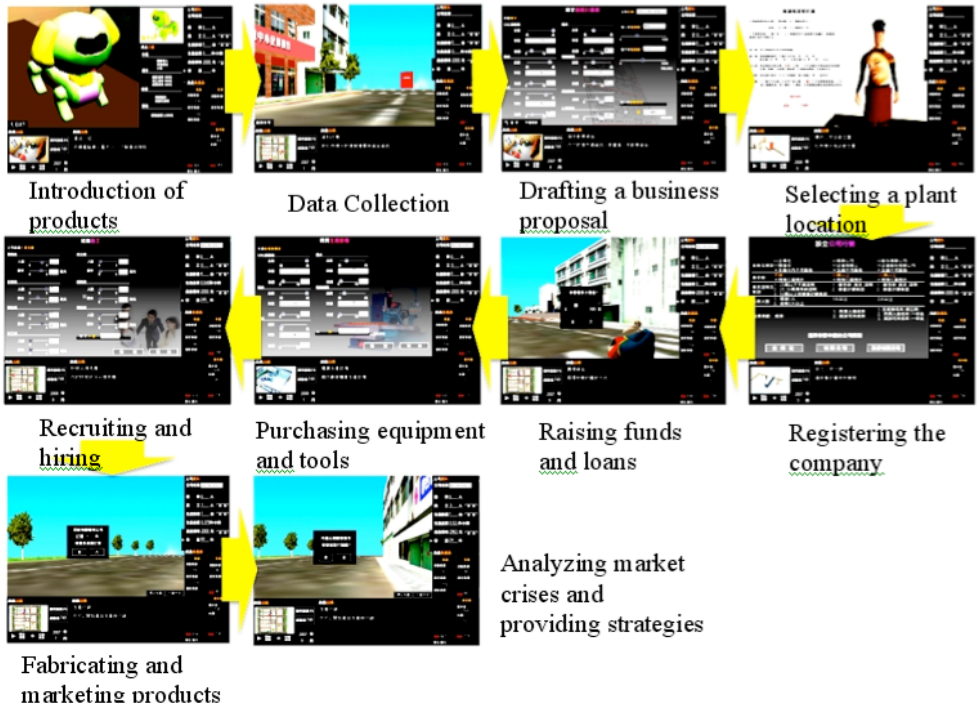


Figure 12. Screens for the Sim Engipreneur system.



4. RESULTS AND DISCUSSION

A sample animation program for Sim Engipreneur is shown in Figure 11. It uses simple connections between function nodes to establish the animation logic and the assessment engine interface. The simulation system starts with introduction and instruction screens to give the background and instructions for the Sim Engipreneur system. The initial screens also give the player a screen to set up the time schedule (as in Table 1) and estimated budget (as in Table 2) of the venture. The game playing duration is 30 minutes, which represents 3 years of the process Jack the engipreneur must go through from the initial planning for his startup business to the end of the first year of production. The main screens of the Sim Engipreneur system will lead the player through the background of the game and the instructions for playing. After the introductory screens, the player will be led through a sequence of screens to complete the eight entreprenurship processes and checkpoints. Figure 12 shows the screens for the eight stages or processes that will pop up during the course of the game to challenge the player.

The proposed entrepreneurship simulation system with Jack's doll design and manufacturing scenario was tested by five students in our laboratory, and two experienced entrepreneurs from the Center for Innovation and Incubation at NKFUST. Their feedback was both positive and encouraging. Analysis of reactions to and suggestions for improving Sim Engipreneur will be presented and discussed in a future article.

5. CONCLUSIONS AND FUTURE WORKS

An engineering entrepreneur simulation, Sim Engipreneur, was successfully developed using a combination of computer-aided tools and techniques. This system provides a means for simulating an important skill that engineers need to develop and for training them as engineering entrepreneurs. Engipreneur players can learn the processes and challenges they will meet in the real world. In addition, because Sim Engipreneur utilizes virtual manufacturing activities to deal with models and simulation instead of real-world objects and operations, it allows players to practice the entrepreneurial activity and learn entrepreneurship knowledge quickly in a risk-free virtual environment. Thus a safe, relevant, and cost-effective learning environment can be provided to students or trainees. This proposed Sim Engipreneur is a shared virtual working environment incorporating features of autonomy, interaction and presence [14]. Initial responses to this version of Sim Engipreneur from experienced entrepreneurs and students have been positive and encouraging. Finally, it should be pointed out that additional study is needed to evaluate and analyze engineering

students' performance in this proposed Sim Engipreneur video game using pre-test and post-test techniques.

6. ACKNOWLOGEMENTS

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