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A Web-based Training Model of Enterprise Resources Planning for the Manufacturing Industry*

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Enterprise resources planning (ERP) is currently recognised as an effective manufacturing management information system that has an excellent planning and scheduling capability. It offers a dramatic increase in customer service, a significant gain in productivity, much higher inventory turns, and a greater reduction in material costs. Many manufacturing companies worldwide have attempted to implement ERP systems. However, there are various researchers who have reported failure cases; they identified training and learning of the ERP system is one of the major factors for the successful implementation of ERP. In this paper the authors attempt to overcome the lack of understanding and training of ERP in manufacturing industry. We propose an ERP training model which integrates with Web-based training to form the framework for training and learning. The model is simulated using System Dynamic—a powerful modeling and simulation methodology of Organization Learning and Training advocated by professor Forrester of MIT. The implementation of this model is described using an example from manufacturing industry. The results are illustrated with this lamp manufacturing company which indicated successful ERP implementation to achieve higher productivity and performances.

INTRODUCTION

ENTERPRISE RESOURCE PLANNING (ERP) has been developed and implemented in the manufacturing industry for many years. According to [1], many ERP users reported reduced inventory needs, shorter cycle time, and benefits including increased production capacity, reduced total logistics costs and reduced manufacturing waste. ERP hardware and software systems gather, manage, automate, and share data on everything from the receipt of materials through shipping to the customer, including accounting, human resources, engineering, market research, purchasing, production and work-in-progress inventory. An ERP system includes advanced planning and scheduling, which gives a company a clear and detailed view of all of its production capacity, and modifies capacity arrangements as needed to adapt to customer requirements. It also monitors e-commerce, or business conducted over secure and efficient Internet connection. In this way, a manufacturer's ERP system is linked, via the Internet, to the systems of its suppliers and customers, so that information can flow freely. Most importantly, an integrated ERP system allows data to be entered in one application and be available to any user, or automatically updated in any manufacturing applications, so that the response time to production can be reduced.

It can be seen that the benefit of ERP is considerable. There are, however, many other reports of failure of ERP [2–5]. These authors pointed out that the failure of the ERP system is mainly due to the lack of understanding and training of ERP [6, 7]. In fact, other studies such as [6, 8] also indicated that most of the failures of the ERP System are due to the fact that the users do not accept responsibility during the implementation process. Most of them mentioned that education is the most important factor for ERP success [9–11]. The authors emphasized that sufficient understanding and training in the ERP system is the key to success. They develop different models to educate people to understand the concepts that are governed by the ERP system. In this paper, the authors proposed an approach to ensure responsibility and effective learning methods for successful ERP implementation.

THE ERP LEARNING AND TRAINING MODEL

Very often generic training offered by system developers mainly focuses on data input to make the system work: the operator only understands the procedures of the system. The training model of [12] identified that one of the key reasons for successful implementation of an ERP system is the fact that the users should be aware about their responsibilities in the implementation process. Moreover, the research in [13] showed that classroom instruction was an ineffective way to develop ERP skills. In order to acquire knowledge and master the process, the approach of problem

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Fig. 1. The model for ERP training.

solving is much more effective. Thus, training is more effective if it is coupled with an operational environment which the system users are familiar with.

In this study, the authors adopt the training model from [12] and propose a new approach in developing ERP learning and training. The model is shown in Fig. 1.

We can see from Fig. 1 that ERP training consists of the following elements:

- *Generic education*. Generic education describes the ERP process and provides some basic understanding of the various modules that comprise the ERP system. Since the background knowledge of ERP of the different users may be different; the operation principle of the ERP system should be described and reviewed to the staff.
- *Application training*. In this respect, the staff needs to acquire some application training about the ERP system. Application training shows the system functions through the description of the data transactions and information flow within the system. Through the experience of hands on practice, the staff can enhance their understanding of the operating principle of an ERP system, and become familiar with the workflow and the details of the operation procedure.
- *Constructive problem solving*. Upon completing the application training, actual problems should be posted to the staff. These training problems should be similar to the daily operational problems encountered by the user. Problem solving is an effective method that leads to a deeper understanding of the capability, functionality, and application of the system. These three elements have been incorporated into the design of an ERP training website, which is further described in the next section.

The model proposed by [12] is reinforced by two components; they are the application System Dynamics (SD) methodology and the use of Web-based tools. According to the 1998 *Campus Computing* survey [14] conducted among some 600 institutions in the United States, the use of IT in college courses increased nearly 6 times from 1994 to 1998. The report also indicates that more than 20 million college staff and students regularly use the Internet and Word-Wide-Web (WWW) in their teaching and learning activities. The change in management and work procedures as a result of ERP implementation demand timely and flexible teaching and learning methods for the workforce which is perhaps best done through distance learning using 'virtual' classroom, using Web-based methods instead of the traditional classroom teaching.

On the other hand, ERP will bring in various changes in the behavior of the company, management and staff. These changes can be effectively modeled using System Dynamics (SD). System Dynamics deals with the broad behavior of the system and how it influences its own evolution into the future which facilitates decision making. It can be seen as the strategic issue which concerns top management in the company. Once the model has been built and tested, the analyst can use it to test alternative policies and to redesign the system so that its policies become more effective. The approach of System Dynamics was created and developed by a group of researchers led by J. Forrester at the Massachusetts Institute of Technology (MIT) in the late 1950s [15]. It is a framework for thinking about how the operating policies of a company and its customers, competitors, and suppliers interact to shape the company's performance over time.

Peter Senge, in his landmark book *The Fifth Discipline*, created the phrase 'the learning organization' [16]. A learning organization has six key characteristics which consists of:

1. The spirit of the organization and personal vision.
2. Building mental models to describe how people and companies view their organization, their competition, and their opportunities.
3. Creating and sharing a common vision.
4. Openness creation by transcending internal politics into game player that characterizes most organizations.
5. The game player can be used in team learning to create a synergy.
6. Using simulation model describes how to achieve a control without in front of the control room.

He further advocated that System Dynamics could be used for simulation and organization learning. System Dynamics provides symbols for mapping business systems in terms of diagrams and equations, and a programming language for making computer simulation. 'Ithink' [17] is one

of the popular tools of System Dynamics and a software methodology for modeling, simulating and redesign manufacturing business. The application of this System Dynamic software on the ERP learning will be illustrated in the following sections.

ERP LEARNING MODEL: CASE STUDY

In order to illustrate the application of Web-based learning and System Dynamics to enhance the learning model in Fig. 1, we describe two ERP learning processes in a Lamp Manufacturing Company. In this case study, an ERP learning center is developed for the general supporting staff to learn ERP anywhere and anytime. For the senior management, a SD training model is developed for them to understand the dynamics of ERP.

The ERP learning website

Web-based training is mainly provided for the general support staff in this Lamp Manufacturing Company about ERP. However, this does not mean that it is the total solution and that the web-based option should be the only one. At the initial stage, Web-training can be treated as the support for conventional, class-room type of training, and the staff can review and gain a deeper understanding of the ERP software. In this stage of the learning process, the development and implementation is simple because the staff already has a basic understanding of the ERP system. Later on, the staff can achieve fully the benefits from the Web-based training.

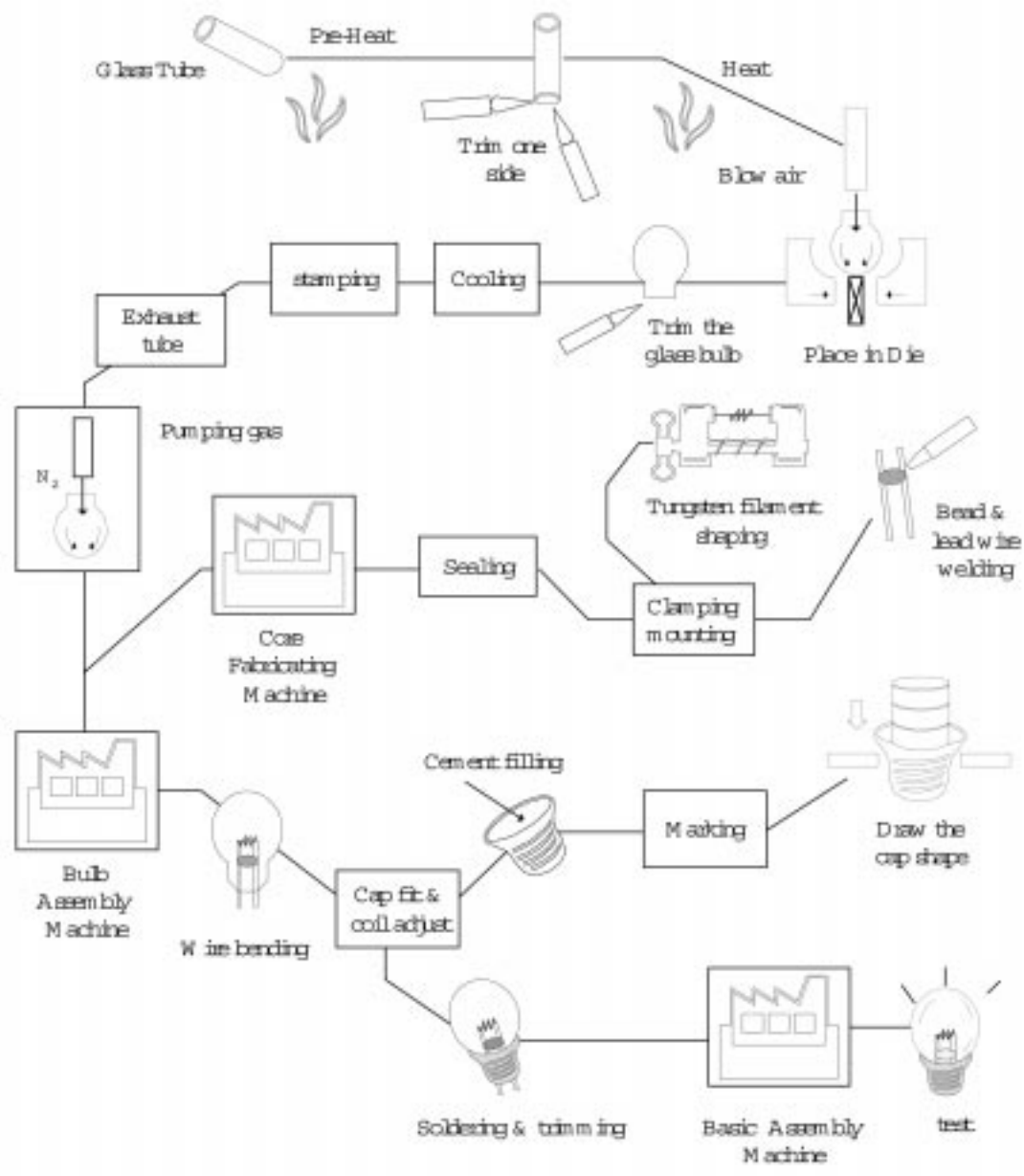

Fig. 2. The lamp assembly line.

In the second stage, ERP Web-based training replaces a major portion of the lecture-based training. In fact, the fundamental training courses teach basic operation principles and the use of ERP commands and usually these are little interactive learning sessions. The following figures illustrate the design of the ERP Web-based training and learning center.

For the general support staff, they need to complete workshop assignments on the ERP website. Several workshops are designed. These workshops provide a step-by-step learning to the ERP process with particularly reference to the manufacture of a lamp product. The objective is to enable the staff to appreciate the operation principle of the ERP system through the recognition of the relationship among the sub-system and the information flow for operation control. The workshop is conducted in three sessions: generic education, application training and constructive problem solving, over the duration of one day, two days, and three days respectively.

Since the website is open to public, the staff can review the principle and concept of the ERP system which belong to the generic education of ERP. For application training, the training is divided into several modules, for example, sales control, bill of material (BOM), production and inventory. Each staff member needs to complete every module together with addition information such as the product structure, manufacturing process chart (See Fig. 2 of the lamp assembly line), sales order quantity, stock inventory data, shop load capacity, etc. The staff is guided to prepare the part master, BOM (Table 1 BOM of typical bicycle lamp), master production schedule, material plan, workshop capacity plan, and the shop-floor schedule. The staff follows the step-by-step Web-based guidebook which provides them demonstrations, and allow them to manipulate the ERP system to verify their findings. In the constructive problem solving, the staff are asked to solve various case studies, such as re-planning the production capacity.

Learning to use system dynamics—'Ithink'

The result of the ERP Web-based learning demonstrates that the ERP education process can become more interactive through use of IT. However, [18] stated that the case method and the traditional teaching methods have a lot of limitations. They cannot capture the feedback from the environments. The management teams cannot obtain a clear understanding of the coordination between the strategy and operating policies. Graham suggests that simulation methodologies such as System Dynamics can help the manager to understand the feedback in real world. Therefore, the author further attempted to develop a training model using 'Ithink' to help the management in learning the ERP systems.

Being the management team of the company, they need to make many decisions and different policies to make sure that the ERP operation is smooth and efficient during the implementation. System Dynamics offers a framework for them to conceptualize complex ERP situations. It is a tool to identify the physical, organizational, and decision-making structures of the systems, and use simulation methods to infer correctly the dynamics of ERP implementation.

In order to illustrate how SD has been used in ERP learning, we developed an SD inventory model to help the manager study the behavior of the inventory in the ERP system. The SD can be used to model the system in dynamics view and simulate the ERP system as indicated in Figs 3 to Fig. 7.

From these analyses, the manager can learn the policies, decisions, and information source for inventory management. In the ERP system, it can be seen that the SD computer-based learning environment is used to support the implementation of ERP; SD training model (Flight Simulator in Ithink software terminology) is developed to

Table 1. BOM of typical bicycle lamp

Part no.	Part name	Source	Qty. per lot	UOM	Lead time (days)	Std. cost
C211	Bicycle (1.2V 0.30A)	F	10000	EA	2	2000
C21-01-03	Glass bulb (C21-series)	F	10000	EA	1	50
C21-03-12	Tungsten wire (Mod# C211)	B	10000	EA	14	200
C21-05-12	Core Assembly (Mod# C211)	F	10000	EA	4	200
C21-05-13	Lamp Body Assembly (Mod# C211)	F	10000	EA	2	300
G00-01-02	Glass rod	B	0.333	KG	30	0.7
G00-01-04	Glass bead	P	10000	EA	0	0.5
G00-01-11	Glass tube	B	40	KG	30	164
G00-02-11	E10 screw base	B	10000	EA	30	2000
G00-03-01	Copper alloy wire (18mm long)	P	20000	EA	0	0.5
G00-03-02	Roll of copper alloy wire	B	0.4	ROLL	60	50
G00-04-01	Paste	B	115.5	LB	14	1650
G00-04-02	Tin/Lead alloy 55/45	B	10.5	KG	14	120
G00-04-03	Flux	B	0.05	L	14	1.5
G00-05-01	Bead wire assembly (18mm)	F	10000	EA	2	300

Note: F, B and P in the 'source' field represent Fabricate, Buying and Phantom item respectively.

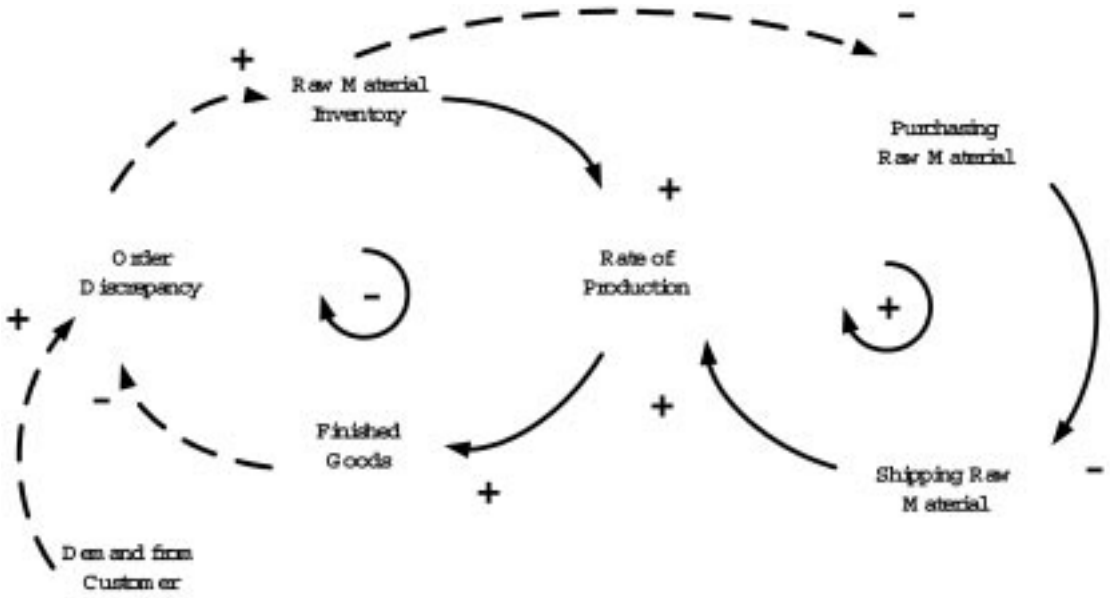

Fig. 3. Causal-loop diagram of JIT inventory in ERP.

understand the behavior of different processes in the ERP system. The following is the inventory behavior of ERP system simulated for the Lamp Manufacturing Company.

Before designing a simulator of inventory for the Lamp Manufacturing Company, the causal-loop diagram is needed to illustrate the flow of the materials and information. Figure 3 shows the causal-loop diagram of inventory of the bicycle lamp. The 'Ithink' software is used to build a flight simulator for JIT inventory in the ERP system. The management team could learn and identify the added value to inventory control. Hence having done the basic generic and application training on ERP concept and functions described earlier, a comprehensive training on the dynamics view of ERP such as JIT and inventory effects, time delay in material flow could be investigated.

There are several features in this JIT simulator. They are the introduction, high level model, simulation (construction model), equation page and control panel. Figure 4 shows the simulation

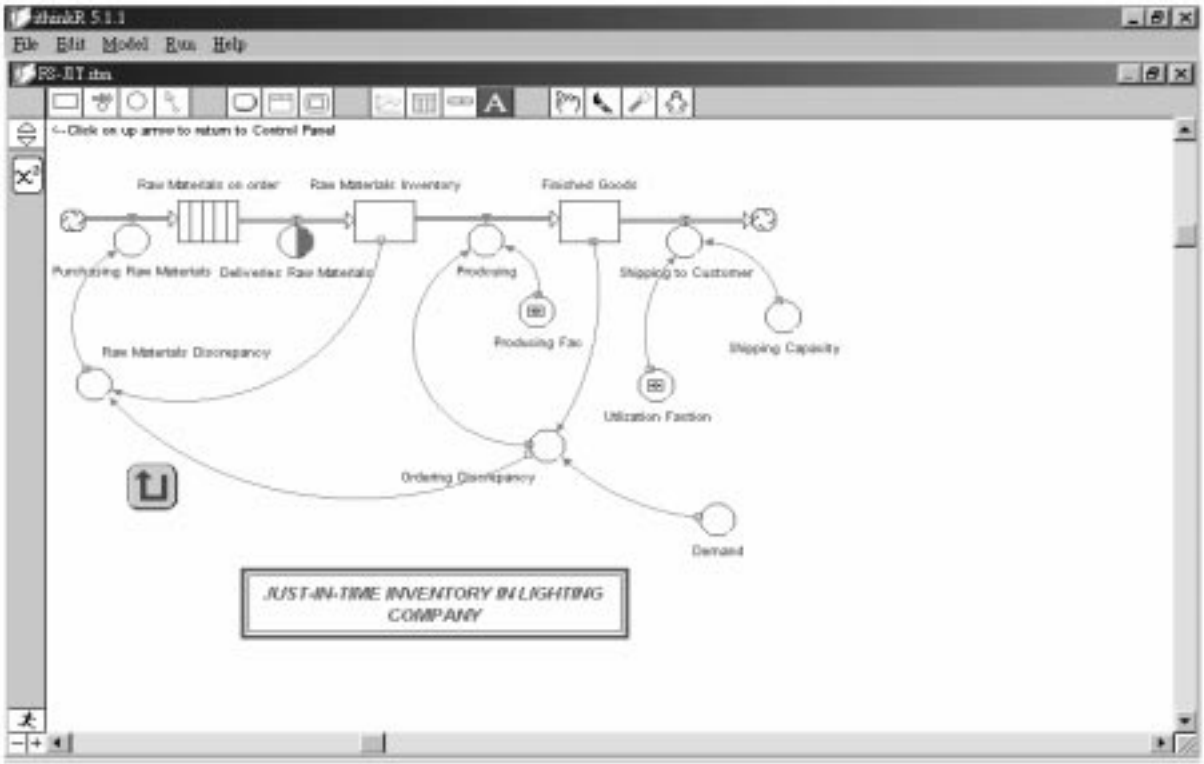

Fig. 4. JIT inventory in ERP.

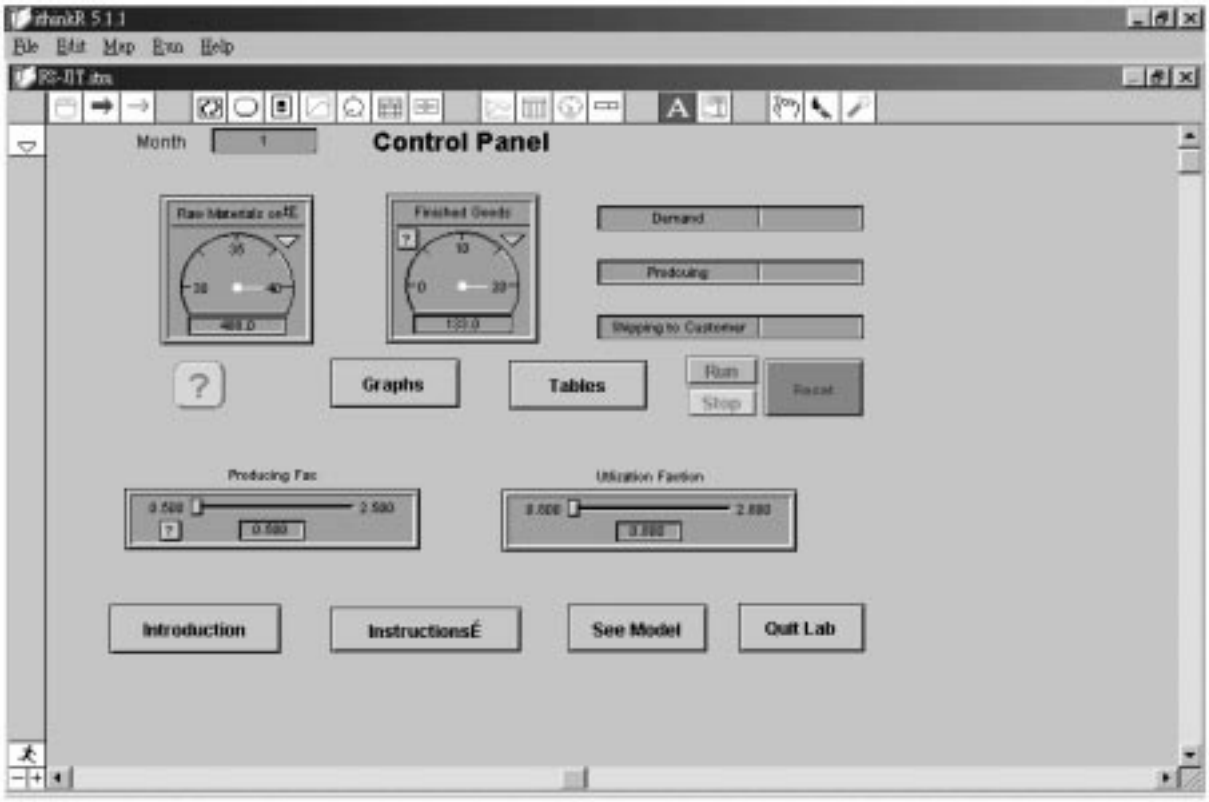

Fig. 5. The control panel of the ERP simulator.

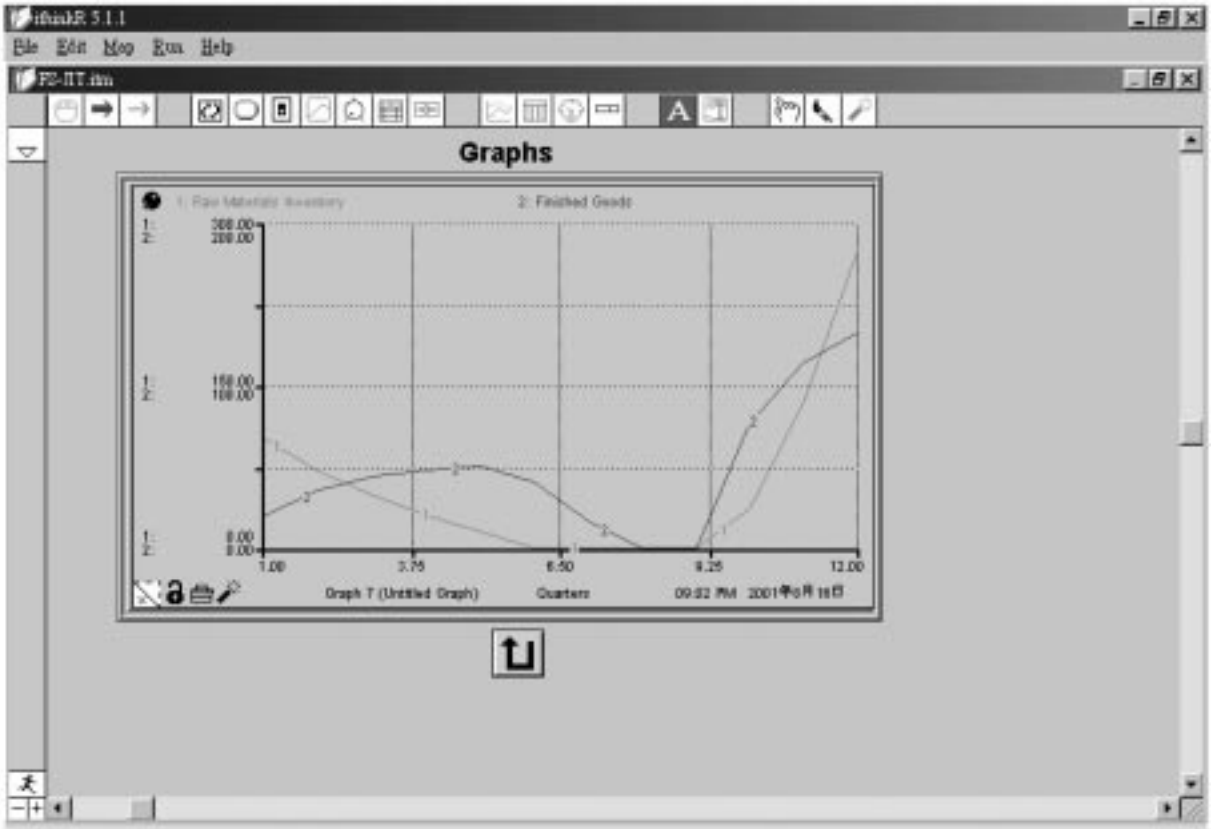

Fig. 6. The graph for input parameters.

Fig. 7. The equation for ERP simulation.

model of the JIT inventory after ERP is implemented. It also shows the information flow for the bicycle lamp manufacturing process. Figure 5 illustrates the control panel for inputting value to simulate the learning model. In the control panel, management can choose their own view using the input buttons which is very user friendly. Figure 6 shows the graphical output of the simulation run which shows the raw material inventory and finished goods after ERP is implemented for a period. Finally, we can modify the equation in the equation page as shown in Fig. 7.

DISCUSSION

In order to enhance the training model of [12], we have incorporated the learning organization using System Dynamic approach. The case study demonstrated that the System Dynamics techniques, with its analysis of variable relationships in a causal-loop diagram, could be adopted for the purpose of exploring the ERP functions and applications. In order to accomplish an effective integration of the SD concept into a practical experience, a series of practice exercise is developed for the lamp manufacturing company in the ERP implementation process. It consists of an instruction sheet containing the variable which can be used in the exercise. All of the variables used in the exercises required the management team to identify where they should be located in the SD loops. In fact, it was decided that it would be too demanding to expect them to draw their own loops. For this reason, pre-drawn loops were included with each set of exercises. The advantage from using 'Ithink' software in our SD models can be summarized as follows:

- To capture new insights into the business when ERP is implemented.
- To facilitate the organizational learning process
- To enable the management team to develop a repository for their growing knowledge base that anyone in the company can access.

Moreover, ERP implementation was designed by adopting the SD approach; procedures and documents were generated from the SD model. During the design process, staff provided their current working procedures. In this way they came to understand an ERP system more thoroughly and hence improved internal communication within the company. The difficulties of ERP implementation described in the literature reviews such as the

lack of communication and the lack of knowledge of ERP have been effectively overcome. Everyone understood the working procedures clearly; mistakes leading to data inaccuracies were reduced.

The ERP Web-based training was used to support original training for the staff within the company. It was divided into two sections of the functions within the company:

- providing information to trainee, achieving feedback and enquiry from trainee, providing material to trainee;
- retrieving customer message; posting information.

This Web-based ERP training approach provides the biggest benefit in that time and is self-spaced. Trainees can use their most convenient time to join the training. Different departments have different roles within a company. Thus, what they need to learn is different. Through this training portal, they can select the module which is most appropriate for them. If a staff does not use the ERP system after training has been completed, the training material can be easily forgotten. Web-based training allows them to arrange training whenever it is convenient.

CONCLUSION

In this paper, the authors describe an ERP training model based on the work of [12], its design and development aimed to overcome the major obstacles to successful implementation of ERP systems in manufacturing industry. The ERP training approach has been tested and developed. It is an interactive training model for the provision of ERP learning in a Web-based environment. The main objective is to expose the staff of the company to practical experiments for training, with problems and exercises that are carefully selected from the industry. When designing the training program, ERP is considered as a company-side system that drives all of the business functions involved in manufacturing. In particular, we have applied the System Dynamics approach to help organization learning. SD offers a number of features that make it easy to apply and, more importantly, to understand. The case study of the Lamp Manufacturing Company indicated that there were several major benefits gained after training:

- Communication among all staff became much better than before;
- ERP implementation time from the initial stage to the trial run stage has been reduced;
- Inventory cost was reduced;
- All staff gains much ERP knowledge and understanding on the procedures of ERP implementation.

Every staff member participated in the construction of the causal-loop diagram and established the ERP implementation and performance measurements which become the major factor for ERP to be successful.

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