Virtual Manufacturing Environments – The Future of Education in Manufacturing

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Abstract
This paper presents some considerations about Virtual Manufacturing and the way in which the Virtual Manufacturing Environments are used in teaching/learning/e-learning. The aspects of information transfer/acquisition by using images are outlined too. The paper presents the structure of an e-learning module in manufacturing engineering, achieved by the authors, and points out some relevant examples. Finally, the way, in which users can manipulate a Virtual Manufacturing Scene via the Internet, is shown.

Keywords: Virtual Manufacturing, 3D animated models, e-learning, Virtual Reality

1 Introduction
In today manufacturing globalization is the major trend, both in terms of markets and partners. This means that the companies want to sell their products all over the world and that the supply chain members are also located all over the world. As a consequence, the information flow among all business actors is dramatically growing and has to be shared. Taking into account this crucial trend it is obvious that education in manufacturing has to follow this route. In other words, today training/learning of manufacturing has to cope with a huge amount of information that has to be delivered/acquired, stored, selected and used. It is generally accepted that Virtual Manufacturing (VM), with all its branches, inclusive Virtual Manufacturing Environments (VMEs), is the key to answer to present/future manufacturing challenges.

Virtual Manufacturing Environments for education in manufacturing might be discussed in various ways. Using Virtual Environments for manufacturing technologies has been in fashion for some time. On the other hand, there is a great enthusiasm for promoting a new IT branch that is Virtual Reality, as a major factor in future environments for training and education.

“The use of a Virtual Enterprise (VE) is becoming increasingly prevalent, and that has been made possible, in part, due to the significant advances in communication and information technology in recent years. A manufacturing system is one of the competitive factors that forms an effective VE” [1].

In its broadest sense, the construction of VMEs has to be seen as a design problem.

The authors think that interactive visualization in product development, training and education as well as for simulating and representing complex technical relationships is the core of future manufacturing, both in education and in real enterprises.

Companies have to manage their products, which are rapidly becoming more complex and varied, for their entire Product Life Cycle, which now spans from development to include a recycling phase. The use of images can enhance communication significantly; hence, one solution could be to link Virtual Manufacturing (Digital Manufacturing) with 3D immersive digital visualisation that enables interaction with the product design through the development process and in the planning and preparation of the manufacturing processes. The costs for creating downstream visual communication for documentation,
training and support of complex tasks throughout the product life cycle are always increasing. To control all these, companies need to balance and optimise among the CAD solutions and visualization software.

The authors believe that a combination between 3DStudioMax and EON Reality software can lead to solve these problems with good results both from economical and technical viewpoints.

2 Virtual Manufacturing

“The term ‘virtual’ has been widely used in many sectors for technical terms such as virtual machines, virtual reality, virtual memory, virtual team, and so on. From the early 1990’s, the word ‘virtual’ has also been used in the manufacturing field. Jones et al. introduced the virtual reality for manufacturing simulation” [2].

In its broadest meaning, the manufacturing can be defined as the way of solving society’s material needs. How can the virtual (digital) manufacturing be defined? First of all, it has to be emphasised that within academic and business environment many terminologies and definitions are used for this concept. Among these, very spread are: virtual manufacturing, digital manufacturing, e-manufacturing, e-factory, virtual factory and so on. As a consequence, a single definition accepted by all the actors involved in the manufacturing area, has not been set up so far.

However, there are some people and organizations that, by their results, can claim the right to establish a definition for this modern and so much in vogue concept in the manufacturing world. In this respect, some opinions are presented below:

"The foundation of digital manufacturing is built upon an open data management platform that can support multiple disciplines, including product design and manufacturing, and share data with complementary applications upstream and downstream for all to participate in as needed”, says Al Hufstetler, vice president of digital manufacturing, business strategy and marketing for Maryland Heights, Mobased UGS PLM Solutions [3].

“Digital Manufacturing -A key tool for better products faster. Digital Manufacturing is the integrated development and manufacturing simulation of a product, which clearly communicates the product and the manufacturing processes for the product” [4].

“Digital manufacturing may have as many definitions as there are vendors to support the concept, but the one thing for sure is that its success rests with the ability to simulate, communicate and act upon digital data system wide. In its truest sense, digital manufacturing comprises technology and business practices that let users collaborate, author, review, design, program, document and share all aspects of a business digitally”[5].

There are three paradigms of Virtual manufacturing (VM), Design-Centred VM, and Production-Centred VM, Control-Centred VM.

More or less, from all these approaches, it is obvious that it can be accepted that VM is a concept that covers the entire Product Life Cycle (PLC) and it integrates the entire information amount and flow by electronic means. VM solutions enable the continuous creation and validation of the manufacturing processes throughout a product’s life cycle.

Two motivations for using VM are underlined bellow:

VM is to enhance people's ability to predict potential problems and inefficiencies in product functionality and manufacturability before real manufacturing occurs.

- “In the future, adaptability of the structure of production will become an important competitiveness factor for companies. However, as company structures change, so also do value-adding structures alter. Future production structures must therefore allow for continuous alterations in planning and configuration. A possible solution is the use of hierarchical system technology for structuring companies. Furthermore, by decentralizing and self-organizing performance units and by networking production right up to Virtual Enterprises, a closer proximity to customers can be achieved”[6].

Using the VMEs in education
There are some areas of education such as physics, chemistry and all engineering branches, where, if learning is too much language-based, conceptual, and abstract, very important side effects might appear. This is due to the fact that they have quite a little "feel" and understanding of the qualitative dimensions of the phenomena they study. Therefore, there is a strong need to root learning in experience. By doing this, the students will get a deeper and more robust understanding of the subject matter.

"Understanding focuses on application and knowledge-in-action offers the best potential for knowledge transfer, the creative application of knowledge, and the construction of new knowledge"[7].

For the areas mentioned above, the education will be extremely expensive and almost impossible in physical laboratories for all subjects of study. On the other hand, the universities can’t afford to keep laboratories at the state of the art. To achieve the goal of setting education on the experience-based track, the VMEs is one of the most appropriate solutions, also from education costs point of view.

To sum up, the advantages of using VMEs in manufacturing education are:

- More effective learning/teaching and quicker comprehension, higher retention, and greater productivity.
- Communicate complex processes at a glance. A well-designed environment can help students experience things in a larger context and pick out useful information from complex systems.
- Reduce training costs. In some cases it might be possible to provide remote access to expensive laboratory hardware.
- Less geographic and language barriers. One can integrate interactive learning objects into a VME and have people learn in that environment by working and communicating with others.

VMEs are generally interactive and 3D and these features maintain trainee interest and involvement, making learning more intuitive and fun.

3D environments have the potential to situate the learner within a meaningful context to a much greater extent than traditional interactive multimedia environments

3 3D animated models the core of VMEs

Generally, three – dimensional (3D) animated models are being created to enable learners to overcome difficulties in understanding/interpreting complex structures, such as a manufacturing equipment/system. Using 3D models for online teaching/learning /e-learning adds a new dimension to the entire process of education. By interaction with 3D animated models the whole teaching/learning process can be greatly enhanced. Till the last few years one would hesitate to use 3D animated models for online education, mainly due to the large size of files and the need for the original software for interacting with the model.

Solutions for creating the 3D animated models, currently available on the market, are quite divers. The authors propose the use of authoring tools such as Flash (from Macromedia) or 3D Studio Max (from AutoDesk). These will offer a good equilibrium between the costs and modeling facilities. The animation to be disseminated is typically authored frame-by-frame using these tools. An important disadvantage of these tools (and this is true for any other currently solutions) is that both require considerable effort for the creation of models.

The authors gained expertise in the creation of 3D digital models for manufacturing processes and equipment using the software 3D Studio Max. Despite the fact that it is very well known among creators in the field of arts, movies, electronic games industries, this software is highly appropriate to create 3D digital models for manufacturing too. Like any other CAD software it has all functions that a creator needs.

Among the main features of 3D Studio Max one might be underline:

- Special effects and rendering facilities.
- VRML features available to publish 3D animated models on the Net.
- Place photographs and film as a presentation's backdrop and integrate sound with the presentation.
- Subtle visual effects.
- Powerful materials editor.
• One of the best modules for animations.
• Using merge command the users can pickup different components from a virtual library and combine them, as they need.

The Interactive 3D and Virtual Reality Software from EON Reality Inc brings the power and versatility of advanced, high-end simulation technology to the PC platform and the Internet. By using the EON Raptor plug-in for 3D Studio Max, the 3D animated digital models can be easily transferred to the EON Reality Studio, where the user can manipulate the scene with EON immerse facilities. Moreover, from Eon Studio it is easy to make an EON type file for Net and, using a free EON Viewer, to manipulate and examine the scene by: panning, rotating, zooming and stopping/starting the animation.

From 3D it is not too complicate to jump to the next step, that is 4D meaning 3D + time. In this way, the learners will visualize the transformation of the manufacturing scene over time.

Interactive 3D/4D models can be obtained both from 3D Studio Max and EON Studio. From 3D Studio Max the developer of the e-learning contents can choose either to export the model as an “avi” file (specific extension for animation files) or as a “wrl” file (specific extension for VRML file). In both situations the user will use free commercial players (like Windows Media Player, Quick Time) and browsers (like Cortona). By using avi files, the learner can stop and play the animation at any segment of time. By using wrl files the end user can interact with the model by zooming, panning, rotating and starting/stopping the animation. The quality of the models is not the best, as might be seen in Figure 1. Nevertheless, the users can freely examine the model, by using the interface buttons.

By exporting the files from 3D Studio Max in EON Studio and creating an “edz” file therein (that is a specific EON file for NET) the quality of the models is considerably improved and interacting with them is very fast (see the samples from Figure 2).

Figure 1: A sample of 3D animated model for Net using CORTONA browser
4. **A sample of e-learning module that uses elements of VMEs**

The e-learning module in manufacturing engineering has two active frames. The first one, a left vertical column, involves the module contents. The second one is a working frame (target frame) and all requested topics will appear here as user order.

The module is structured on 4 levels. In the first level the user might have contact with the home page (see Figure 3). In the left frame, the chapters of the module are set up, such as: manufacturing, products and parts, materials, primary manufacturing processes, manufacturing by machining, classical machining, no conventional machining, NC machining and machining centers and so on.

The second level of the module appears when the user asks for a topic by clicking one of the chapters (main heading) from the contents. If for example the user wants to study about NC machining and machining centers, he will click on it and in the target frame will appear all the subchapters related to this topic (see Figure 4).

Further on, the user can choose any subchapter from the menu and thus enter the third level of the module. Here, the topics are treated by means of text, sound and by 3D (in fact 4D) animated models both for processes and equipment. The main feature of the e-learning module is that it uses a large amount of such models at all steps. The models appear in the third level, but to get closer to these the user has to go to the fourth level, by clicking the icon net to the model (see Figure 4 and Figure 5).
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The module can be delivered both on CDs and via the Internet.

5 References


