

Conventional to Virtual Laboratory in Vocational Education

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Abstract

Laboratories and workshops on vocational education is the primary facilities in the formation of student competence. On the other hand the operational costs to be paid to the implementation of practical learning is very high, so that vocational education institutions have problem in teaching and learning lab. There is always a gap between the ideal and reality in teaching and learning in laboratories and workshops.

The development of computer software technology is very beneficial to the teaching and learning process in vocational education in Indonesia. Huge cost in the purchase of equipment, lab maintenance, and purchase of lab materials will be reduced by using virtual laboratories or virtual workshop. At this time the virtual media can replace the real with the perfect condition. Expensive equipment, dangerous and complex operation can be replaced with a virtual environment that can reduce the cost and time. This article will discuss the use of virtual media in learning CNC machining for vocational education. The process of learning by using a virtual laboratory in several fields have been proven to enhance students' cognitive understanding, accelerate the learning process, and reduce costs.

Keywords: virtual laboratory, competence, vocational education.

Introduction

Learning process in vocational education requires adequate facilities and infrastructure. Standard facilities and infrastructure SMK / MAK which has been established with Permendiknas No. 40 of 2008 is a reference to create classes, laboratories and workshops. For vocational schools that do not have the laboratories and workshops, it is very hard to meet these standards, because it requires huge funds for investment. In the standard facilities and infrastructure, the virtual lab standards have not been listed. Virtual laboratory is a laboratory clone obtained through the use of computers and software. According to Sahin, et All (2008) the main advantage of virtual media use in the training are: cost savings, safety, and access flexibility.

The application of computer software technology in teaching and learning in some vocational education in developed countries has become commonplace. Technical Drawing lessons that previous using a drawing table, drawing machine, pencils, paper, has been changed to use drawing software such as AutoCAD, Solidwork, Corel Draw and so forth. The use of conventional production machines in the company have been very rare since been replaced by machines controlled by computers. From observations of the

author in three medium manufacturing enterprises in Yogyakarta obtained results that for the production of machine components is almost 100 % using a computer-controlled machines. On the other hand in many vocational high schools is still more to teach the operation of conventional machines, so there is a discrepancy between what is taught to what would be experienced by students when working later.

Facilities in most of the vocational school, particularly for machining competencies study program, at present using machining workshop containing a conventional machine tools: lathes, milling machine, drilling machines, grinding machines, and shaping machines. Some schools have more advanced machine tools and has used CNC (Computerized Numerical Control) machining laboratory to practice the operation of CNC machines tools for their students. Problems that arise in learning CNC machining is what to teach and how to teach. In this article will discuss the use of instructional media in the form of CNC virtual machine tools or the use of virtual labs to form a vocational high school students' competence.

Virtual reality as learning tools

It can be argued that the ultimate goal of education, at any level, is to prepare the learner

with the skills needed to succeed in life (Aldrich, 2002). To maximize their instructional effectiveness, career and technical education (CTE) programs need to apply effective Learning tools in their classrooms and laboratories. Recent literature reviews of published research have consistently documented the effectiveness of virtual reality (VR) as a learning tool in a variety of settings. The research has shown that many educational institutions, industries, and organizations are now turning to VR to provide effective and cost-efficient ways of teaching and career preparation and development. The field most actively reported in the VR literature is medical/dental, where large numbers of published studies have attested to VR's benefits. Engineering has also reported considerable success with virtual reality instruction. Use of VR for both career training and for product development has also been reported for several years in a variety of other industries such as aerospace, petroleum, equipment design, vehicle prototyping, lathing and manufacturing, accident investigation and analysis, law enforcement, anti-terror response, hazard detection, crane driving, aircraft inspection and maintenance, and facilities planning (Ausburn, 2009).

The desktop virtual reality uses QuickTime, Java, or Flash technology to present high-resolution panoramic imagery on a standard desktop computer. Desktop VR "movies" are created by taking a series of digital still photographic images and then using special VR software to "stitch and blend" the images into a single panoramic scene that the user can "enter" and explore individually and interactively. The user employs a mouse to move and explore within an on-screen virtual environment as if actually moving within a place in the real world. Movements can include rotating the panorama image to simulate physical movements of the body and head, and zooming in and out to simulate movements toward and away from objects or parts of the scene. Embedded individual virtual objects can be "picked up," rotated, and examined as the user chooses, and clickable "hot spots" can also be used to navigate at will (Ausburn, 2009). What characterizes these desktop VR movies and distinguishes them from traditional video is that *the user* chooses where, when, and how to move, explore, and examine rather than being controlled by the prior production decisions of a videographer (Ausburn & Ausburn, 2004). Noe (2008:290) define the virtual reality as a computer based technology that provides trainees with a three-dimensional learning experience. Virtual reality allows simulations to become even more realistic. Using specialized equipment or viewing the virtual model on the computer screen, trainees move through the simulated environment and interact with its components.

Virtual environments provide safe and cost-effective environments for learning and "hands-on" training. Recent strides in computers and graphics cards speeds are making it increasingly more realistic (i.e. closer to physical environments) especially from the visual and auditory perspectives. Accordingly, Virtual environments are becoming increasingly attractive in education and training applications (Wasfy, 2008). A recent review of the literature found that nearly half of the research studies on the development of products and tools dealt with computer-based or Web-based instruction (Richey,2009:20). The descriptions below are the example of CNC Machining training centers used virtual laboratories/ machine.

SinuTrain – the efficient SINUMERIK CNC training system

With the option "Virtual machine designed for training purposes", SinuTrain offers – through a 3D simulation of the machining process – reality-identical system operation increasing the efficiency of CNC training (Figure 1). This option allows to "manufacture" workpieces on the PC using reality-identical processes, on the basis of three implemented machine types – including one milling machine and two turning machines, one of these equipped with a counterspindle. The advantage of it is the customer need not buy expensive machines. When the machine purchase costs are too high on account of reduced budgets, the "Virtual machine designed for training purposes" is a low-cost alternative to CNC training.



Figure 1. SinuTrain Training

Emco Industrial training

TrainConcept is a multimedia training program that teaches all the basics of modern CNC technology. TrainConcept's cleverly-designed teaching format makes even complex concepts easy to grasp and learn. Interactive dialog features allow trainees to progress at their own pace. Views are displayed using attractive 2-D-graphics and 3-D-graphics, animations, and videos, taking the work out of learning and making lessons memorable. The course can be taken either on a PC or via an intranet or the Internet (Figure 2). TrainConcept is the ideal teaching platform. Videos can be moved, zoomed

or slid. The software includes interactive 3-D-objects and users can move, enlarge and shrink graphics using the mouse and the animations can be manipulated.



Figure 2. EMCO CNC Training

VTC for CNC

The Virtual Training Centre (VTC) was set up on the Internet for Computer Numerical Control (CNC) training based on virtual aids. A virtual space (a CNC training portal) on the Internet which allows the constant sharing of e-learning-based CNC teaching material was created so as to foster the further development of e-learning based CNC educational contents. The equipment, methods, curriculum and techniques currently used in CNC training by partners were observed, collected and evaluated. The selected materials were used to create the new and common curriculum on which this VTC was based. This curriculum was taken as the core of virtual training activity. Depending on this curriculum, an interactive teaching program was developed and put into a website to form a virtual training centre. The site, along with the interactive teaching program, consisted of four main areas: "News", "Exchange of Views", "Links", and "Resources". Thus, users will be able to access, to name a few, to the newsletter, a bulletin board, online surveys and survey reports, information on VET networks, an electronic library with references, a bookshop with downloadable publications and a number of databases.

LearnHaas.com : Virtual Training Environment CNC Machining

The Virtual Training Environment for CNC Machining combines *powerful* "flight-simulator" technology with a *flexible* Internet-based learning content management system to deliver a truly innovative learning experience. Unlimited access to train and rehearse in the Virtual Training Environment for CNC machining enables learners to develop greater confidence and proficiency prior

to performing actual procedures and operating equipment (Figure 3). *Mill* and *Lathe* CNC online courses provide the learner with comprehensive learning content, interactive exercises and virtual CNC panels and 3D machines.

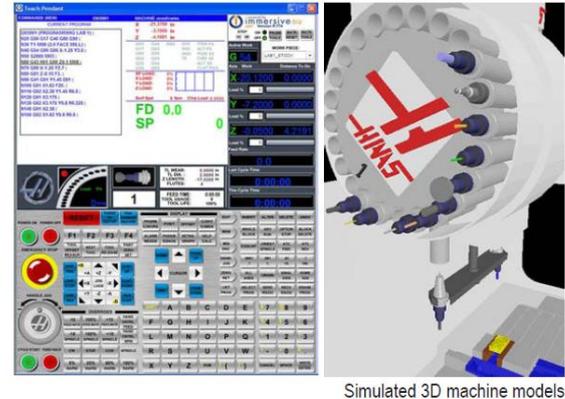


Figure 3. Interface of virtual CNC panels

Swansoft CNC Simulator and CNC Virtual Machine

Based on factories' manufacturing and colleges' teaching experience, Nanjing Swan Software Technology Co.Ltd developed the following software: FANUC, Sinumerik, Mitsubishi, GSK, HNK, KND, DASEN, and simulation software for CNC machine tools. Through which, we can attain the aim of enabling students to have the experience of practical manipulation on a largely-reduced cost (Swansoft, 2007). This software has the advantage of the machine control panel can display that functions like a real machine or virtual CNC machine tool. In addition the machine settings, selection tools, and workpiece clamping look like the real machine that is displayed on computer monitors. Swan series NC simulation software can be further divided in 8 major types, 28 systems and 62 controlling surfaces. Equipped with FANUC, SINUMERIK, MITSUBISHI, GSK, HNK, KND, DASEN software, swan CNC machine simulation software can help students to learn operation of CNC milling tool, lathe and machining center of each system.

The advantages of Virtual Laboratories

The virtual CNC laboratories can be used to provide hands-on training on the operation of CNC machines. The students can also experiment with the virtual machines and test operating procedures and CNC programs. Hands-on training and experimentation enhance students learning and retention and increase students creativity and problem-solving capabilities. In addition, the virtual CNC machine provides an effective knowledge capture and reuse capability. The traditional knowledge capture method of relying on operating manuals fails to capture the dynamic and time-

dependent aspects of operating CNC machines (Wasfy,2005).

Virtual CNC machines (Simulator) can attain the aim of enabling students to have the experience of practical manipulation on a largely-reduced cost (Swansoft, 2007). Simulations are best used according to Aldrich (2002) in three situations: (1) simulations can be used for developing ideas and concepts that which only experience can strengthen its understanding, (2) simulations are good for giving people practice in decision-making before they are faced with real-life situations that can be dangerous or critical, or for issues that deal with time or scale, and (3) simulations allow people to experience a time or place that they are unlikely to experience directly (Figure 4).

The three main advantages of Virtual training environments over traditional training on physical CNC machines are: (1) *cost*: the Virtual training environment runs on Windows and Linux based PCs. Thus, small colleges can provide CNC machining training without investing a lot of money to setup a CNC machining lab. Even for larger colleges, there could be budget limitations that prevent the initial investment (especially, for sophisticated machines) or the subsequent upgrading to keep up with the changing technology. In addition, the virtual machine saves money on consumables such as tools and workpieces, (2) *safety*: the students can experiment without risk of damaging expensive equipment and facilities or injury, and (3) *Access*: unlike manufacturing labs with limited lab hours and required supervision, the virtual CNC machine is easily accessible at any time without supervision and can be accessed via the Internet. Noe (2008:308) state that simulations and virtual reality is the best computer based training methods compare to the other. Simulations and virtual reality can improve the learning outcome (verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills). *Sim Tech* (<http://www.SIMTech.a-star.edu.sg>) said that the use of virtual machining or training simulator can help educational institutes enhance the quality of their CNC training courses as well as reduce by more than half capital investment in CNC machines and training consumables. The benefits include lower capital investment and operational costs, elimination of injury risks and damage risks to machines, raw stocks and toolings.

Conclusion

Increasing the efficiency and effectiveness of learning CNC machining competencies in vocational high schools can be done by learning the practice of CNC Machine tools. Implementation learning for CNC machines tools can be done with computer -based learning method uses a virtual CNC machine. The use of virtual machine has

advantages: saves costs, save time training, safety, and can be accessed anytime.



Figure 4. Vocational High School students learn CNC with virtual CNC machine

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