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INTEGRATING NETWORK, CAD AND VR INTO THE DESIGN AND DEVELOPMENT OF WEB-BASED COMPUTER GRAPHICS LEARNING MATERIALS

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ABSTRACT

The purpose of this research is to apply the principle of constructivism to the design of Web-based training systems for teachers and learners. Several issues will be addressed in this paper including the development of a Web-based Interactive Design Graphics (WebDeGrator) to create a better learning environment.

In this paper, we discuss the development of a web-based learning system to simulate and adjust computer graphics through Bézier, B-spline and NURBS algorithms. The features of Computer-Aided Design (CAD) and Virtual Reality (VR) are integrated in a network system. Another advantage of this proposed graphics system is that it is portable across different operating systems such as Windows 2000 and Linux because the network browser is a common platform in the Internet and Intranet. In fact, this graphics system is capable of sharing resources with each other.

Keywords: ***Web-based, Surface, Curve, NURBS, Graphics, Learning, Virtual Reality, Constructivism***

1.0 INTRODUCTION

As the Internet has improved in the last ten years, a web-based system of graphics learning has emerged and become very important in the Internet. In recent times [1], distance learning using the Internet has been established and developed in the Web-Based Virtual Reality Instruction system [2]. In the paper, a web-based system is developed for users to design and learn sculpture curves and surfaces on a personal computer interactively. This graphics system has a friendly interface in operating procession.

The implementation of this graphics system is mainly based on the functions of OpenGL, which is capable of showing complex 2D and 3D graphics. The platform of this learning system is a network browser and VR-based browser. Users can draw curves or surfaces via assigning these points in the graphics area. When the user has accomplished setting the control points successfully, he can drag the control point on the curves or surfaces to modify the graphics in real time. Then the user can select to save files or change the values of other variables on the curves or surfaces such as weight, color, etc. Finally, the user can convert the browser graphics to a VRML file which can be realised on the VR browser.

The purpose of this study is to develop an integrative graphics learning system in real time - Web-based Interactive Design Graphics (WebDeGrator). Drawing the complex curves and surfaces in the network browser instantaneously is a new technology nowadays. In this work, we combine the Web with CAD to create a brand-new idea of great originality.

2.0 DEVELOPMENT ENVIRONMENT

In our daily life, the World Wide Web (WWW) is one of the most important services relating to the Internet because it has already contained all kinds of multimedia in itself such as text, images, graphics and sound [3]. While WWW has become more and more popular, the development of multi-dimensional computer graphics, web-based technology, and virtual reality (VR) have increasingly grown and become significant subjects to be studied [4].

On the other hand, since computers have become increasingly faster each day, several 3D graphics and VR applications can be realised on a cheaper computer such as personal computers (Intel inside PCs) or some low-cost workstations. Basically, 3D graphics and VR have changed the computer world from flat to become three dimensional, and from one-way static output to emerge as two-way interactive displays.

Recently, several famous computer companies have proposed to combine the 3D graphics and VR capabilities with the Internet. The designer of Virtual Reality Modeling Language (VRML) said: "because the world is not flat" [5]. Most media currently supported by WWW are using 2D media; for example, text, images and two dimensional (2D) animation. There are only a few 3D graphics and VR media available for users to perform 3D on the Internet.

3.0 WEB-BASED INSTRUCTION

The World Wide Web (WWW) is an exciting new medium for the development of class-room activities. The advent of the WWW was so fast that much of the design for web-based instruction (WBI) has been profit-making in terms of educational settings, focusing on the technology rather than theory [6]. The design of web-based instruction should focus not only on the technology but also on the goals of the class, the needs of the learner, and the nature of the task involved [7]. Therefore, there is a demand for more sound research regarding the effect of WWW on learning.

Reeves [8] conducted a survey in 1995 with regard to 650 two- and four-year colleges and universities on their use of the Internet and WWW. The results revealed that there are over seven million students and faculty members who use the Internet and WWW routinely, yet there exists only 6% of all courses that are currently tapped into the web resources. Clearly, there is a lack of integration of WWW into the actual teaching and learning. At the present time, most WWW applications are: upgrading access to course materials, documenting course discussions, searching course glossaries, posting projects for critiques, providing course reference material, displaying students' writing and art, providing tutorials and drills, facilitating group work, providing learning support, engaging in collaborative web projects, and enabling reflection [9].

The WWW cannot guarantee the success of learning. The rich media and linkages available on the Web are not unique to WBI. What is so unique about WBI is the pedagogical dimensions that can be designed to deliver. Sound pedagogical dimensions must be considered when designing WBI; these dimensions of learning can determine the WWW's ultimate effectiveness and worthiness [10]. Factors such as the object of the goal, interactivity and learner's supervision, multiple media, motivation, and structure must be taken into account in the hypermedia environment such that the design of WBI would enhance the educational opportunities of the learners.

Laurillard recommends that high-quality learning at the university level contains the following characteristics [11]:

1. ***Situational***:
   The learning of knowledge cannot be separated from the situations in which it is used.
2. ***Interactive***:
   Knowledge is built by the interaction between students and teachers, students and students, and students and the material.
3. ***At least part of learning is domain specific***:
   Knowledge is best understood in its content domain.
4. ***Reflective***:
   The learner benefits by being able to reflect upon what has been learned and the process of learning.
5. ***Learning is about experiencing the real world***:
   Knowledge is grounded in the world in which the learner lives.

These components of university learning describe a complete process rather than specific learning activities. They imply that learning involves bringing together the above components in a planned interaction between the student and the information, with opportunities for teacher interaction and other students, as required. It seems reasonable that a delivery, which supports the above characteristics, is likely an appropriate one. In turn, the technology that supports and enhances this process is likely to also be appropriate. However, as stated previously our system records every student's learning activity automatically, which assists students in learning.

In trying to understand the learning process, research has focused on the acquisition of meaning and interpretation of knowledge as well as information and skill recall. There are a variety of approaches to learning [12]. Those, which are deep, are associated with a higher quality of learning. For example, our system presents several problems, for which the CAD curriculum material can be reviewed and discussed. Both experiential and collaborative learning foster a deep approach.

4.0 FEATURES OF WEB -BASED LEARNING

Web-based learning (WBL) contains open, flexible and distributed learning environments. Design, development, implementation and evaluation of open, flexible and distributed learning systems require thoughtful analysis of the WWW potential in concert with instructional design principles that are relevant to various dimensions of online learning. Badrul developed a framework for web-based learning [13]. These WBL factors encompass various web-based learning and support our WebDeGrator research as illustrated in Fig. 1.

Fig. 1: Web-based learning framework [13]

4.1 Flexible Learning

Flexible and open learning can be viewed as a solution to widen access to various courses, including CG ones. Wong and Ferguson presented that three basic factors can be employed to describe learning [14]: learning style, control and focus. The first refers to information processing. The second refers to the degree to which the student, rather than the teacher, controls the learning activities and instructional strategies. The latter refers to the emphasis, which is placed on providing support to student-centered learning, as opposed to traditional teacher-centered teaching. These three factors can be employed as various dimensions to learning as shown in Fig. 2.

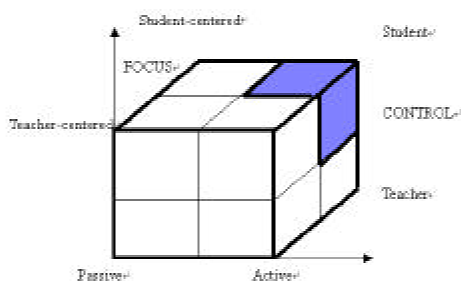


Fig. 2: Dimensions of learning

Fleming summarised the practice of flexible learning as methods of organising and applying learning by offering a student a more active and constructive role within a framework in which goals can be pursued independently [15].

Flexibility supports situational learning by offering various situations to individual students. This is significant due to the different backgrounds and levels of understanding that are brought to the learning process. Flexible approaches to teaching and learning allow for more appropriate linkages between the CAD curriculum materials being delivered as well as the situations in which students apply this material.

4.2 Application Sharing

This is a feature that allows two or more people at various locations to work together with the same software application concurrently. During application sharing, although one student initiates the application program, it appears on all participants' computers simultaneously. All learners can input information and control the application via an input device. The proposed graphics system is adaptable to various operating systems, such as Windows 2000, 98 and Linux, as its network browser is a common platform in both the Internet and Intranet. In fact, the proposed system is capable of sharing the resources with each other. Students enrolled in the same course can share work by viewing the web portfolios.

4.3 Asynchronous Function

This is a communication that occurs with a time delay, allowing participants to respond at their own convenience. Asynchronous programs provide access to course materials including readings, embedded streamed multimedia, and external Web sites. They also facilitate discussions and enable individuals as well as collaborative work. The proposed learning system can be accessed anytime, anywhere, and in any form.

4.4 Browser Interface

This denotes that via a VRML-enabled browser, such as Internet Explorer or Netscape Navigator/Communicator, most features can be employed. It is widely believed that software has been added to the browser, such as VR-browser, to increase its selective functionalities. Our system is based on VR-based browser and provides more interactive 3D interfaces.

4.5 Computer-Based Training (CBT)

This is an approach in which the computer provides a series of interactive and instructional stimulus to the student, which ranges from questions to decisions. The CBT then provides feedback based on the student's response. In our system, CBT was applied to construct knowledge and experience. The learning flow is then circulated until a student exits the system. Conventional multimedia training involves a visual fashion. However, with VR, a user can also interact and is not merely an observer. VR can bring the equipment and actual working conditions to the user for unlimited access in any location. Fig. 3 illustrates that VR is a better training tool than conventional class-room and laboratory training methods [16]. Furthermore, when VR is employed as a training technique, time spent teaching can increase significantly.

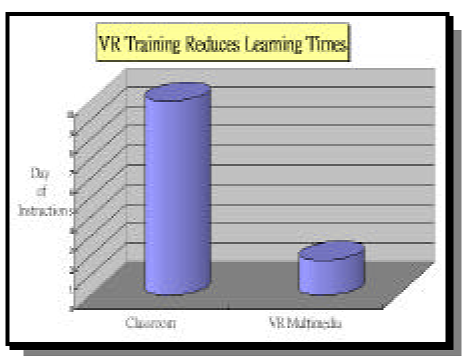


Fig. 3: VR as a training approach, as opposed to traditional class room techniques (RTI)[16]

4.6 Distributed Learning

The WebDeGrator learning system offers a variety of technologies, such as learning methodologies, on-line collaboration, and instructor facilitation. In turn, due to the fact that it is truly flexible, anytime/anywhere fashion, which traditional education system cannot achieve, it yields desirable learning results.

4.7 Real Time

The WebDeGrator learning system allows students to adjust and modify graphics in real time, which is the most noticeable feature in the web-based learning system. In analysing and generalising related research, we found that all previous research neglect real time in their development of web-based learning system.

4.8 Web-Based Training (WBT)

This is a form of computer-based training, in which the training material resides on WWW pages. The WebDeGrator learning system applies the WBT principles to CAD curriculum material. Students passively learn CAD curriculum material through system's assignment. Typical media, which the proposed system employs, are text and graphics. However, although they require increased bandwidth and in some cases additional software, subsequent media such as animation, audio, and video can also be used. The terms online courses and web-based instruction are occasionally used interchangeably with WBT.

4.9 Collaborative Learning

Collaborative learning is defined as groups working together for a common purpose [17]. Collaborative learning deals with instructional methods that seek to promote learning through collaborative efforts among students working on a given learning task [18]. Computer supported collaborative learning (CSCL) delivers a collaborative environment that focuses on learning [19, 20]. In a constructivist process, WebDeGrator allows students to share learning experiences via Web portfolios. The system assistant also guides students towards their next accomplishment based on the student's web portfolios. Among students, assistant and WebDeGrator learning system, collaborative learning theories will be implemented and realised on constructive knowledge and experience.

In summary, most of the afore-mentioned theories reflect student-centered learning practices, which have emerged recently to counter behavioristic models of educational environments. The development of learning technology has also shifted from a highly guided to a more open learning curriculum, namely in the manner in which new resources are formed to support new teaching and learning methods.

5.0 WEBDEGRATOR-WEB-BASED INTERACTIVE DESIGN GRAPHICS

Curve and surface design is an interdisciplinary issue involving a theoretical background, which is based on mathematics, computational algorithms, and engineering applications [21]. This unique design has great potential for research and software development. However, due to its complexity, it is problematic for inexperienced undergraduates. For example, owing to its complicated mathematics, learning curve and surface design in a CG course is a challenging task and often omitted. Moreover, although software engineers and programmers are required to have CG and CAD expertise, many computer science educators believe that curve and surface design is not curriculum-related [22]. Furthermore, despite the fact that mathematics is the basis of geometric design and modeling, mathematicians rarely investigate them in their curricula. Recently, most major CAD systems have included curves and surfaces, especially B-spline and NURBS. However, engineering curriculum has focused only on the use of existing systems rather than reviewing the basis of these systems. This oversight could pose a serious dilemma for a design, as this inherent lack of understanding can result in inaccuracies.

To effectively resolve the above-mentioned problems, an interdisciplinary course, Interactive Real-Time Computer Graphics System has been designed for engineering, computer science and second-year science students. This course encompasses important topics that are frequently used in computer graphics, geometric design, computer-aided design, and visualization. A pedagogical interface tool, Web-based Interactive Design Graphics (WebDeGrator) as shown in Fig. 4, has also been designed to learn curve and surface design. This course employs an intuitive and non-mathematical approach, which enables students to rapidly and efficiently learn the fundamentals instead of spending too much time on mathematical derivations and algebraic manipulations [24].

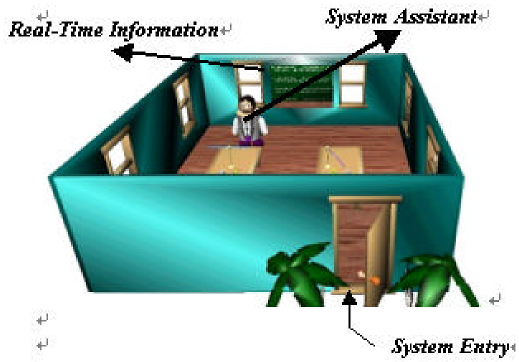


Fig. 4: An Interactive Real-Time Computer Graphics System-WebDeGrator [23]

Moreover, WebDeGrator provides students with an interactive environment so that they can grasp basic concepts and algorithms. While commercialised software product can be employed for this purpose, a simple system that isolates the students from complexity and complicated operations facilitates the pedagogical process. Technically, WebDeGrator is a system designed to aid both teachers and students to conduct the academic training interactively without the restrictions of differing operating systems.

This work addresses all three types of parametric curves and surfaces, i.e. Bézier, B-spline and NURBS. Our discussion starts with the hierarchy of these curves and surfaces as illustrated in Fig. 5 [25].

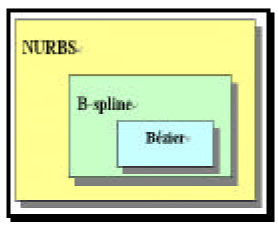


Fig. 5: The hierarchy of these curves and surfaces [25]

6.0 SYSTEM FEATURES

In reality, designers or users usually do not worry about the mathematics and equations that establish the framework behind the software. They are more or less focusing on getting their job done. Therefore, a system that supports users to design curves and surfaces must possess the following characteristics [26].

1. ***Intuitive:***
   It is expected that every step and every algorithm should have an intuitive and geometric interpretation.
2. ***Flexible:***
   The system should provide the users with more flexibility in terms of designing and editing the shape of a curve and surface. The way to create and edit a curve and surface should be done easily and geometrically without the manipulation of equations.
3. ***Unified Approach:***
   The method to represent, create and edit different types of curves and surfaces (i.e., lines, conic sections and cubic curves) must be the same. That is, it does not require different techniques for manipulating different curves and surfaces (i.e., conics and cubics).
4. ***Invariant:***
   The representation of geometry of curve and surface will not be changed as a result of geometric transformations such as translation, rotation, parallel shift, and perspective projections.

5. ***Efficiency and Numerically Stability:***
   A user utilising a curve and surface design system may not be concerned about the delicacy of the underlying geometry; but he definitely expects the system to deliver the curve and surface he wants fast and accurately. Moreover, this proposed system allows large amount of computations without causing any distortion of the shape and the curve (i.e., numerical stability).
6. ***Portable and across different platform:***
   A network browser is a common platform. In the Internet and Intranet, the graphics system can be portable across different operating systems such as Windows 95 and Linux.

7.0 WEB-BASED LEARNING THEORIES - CONSTRUCTIVISM

Many researchers and educational practitioners believe that VR technology has provided new insight to support education. For instance, VR's capability to facilitate activities of constructivism learning is one of its key advantages. In contrast, others have focused on alternative forms of learning - such as visually oriented learners - as potential to provide support for different types of learners. Still, others see the accessibility for learners, and educators to collaborate in a virtual class that transcends geographical boundaries as a major breakthrough. In traditional learning environments, students are expected to learn by assimilation, i.e. by listening to an instructor's lecture on a specific subject. Currently, the current learning approach is that students are better served mastering, retaining and generalising new knowledge, while they are actively involved in applying that knowledge in a learning-by-doing environment. This is a philosophy of pedagogy, deemed constructivism. Notably, its supporters range from those who consider it a useful supplement to teaching-by-telling to those who argue that the entire curriculum should be reinvented by gently guiding students with discovery learning [27].

Jonassen noted that there is a primary difference between traditional instructional design and constructivism [28]. That is, the former focuses on designing instruction that has predictable outcomes and on intervening during instruction to map a predetermined conception of reality onto the student's knowledge. While, the latter focuses on instruction that fosters the learning process, rather than controlling it. Jonassen also indicates that a constructivist focuses on learning environments, rather than instructional sequences, recommending features such as those identified in Table 1 [28]. Originally, the proposed graphics system was established based on the concept of constructivism. Clearly, constructivism is the predecessor that results in the proposed web-based graphics system.

Table 1: Constructivist Learning Environments (Based on Jonassen & Jonassen, 1983 [28])

1.	Provide multiple representations of reality, thereby avoiding over-simplification of instruction and representing the natural complexity of the real world.
2.	Focus on knowledge construction, not information reproduction.
3.	Present authentic tasks (contextual quality that excites enthusiasm rather than abstracting instruction).
4.	Foster reflective practice.
5.	Enable context - and content-dependent knowledge construction.
6.	Support collaborative construction of knowledge through social negotiation, not competition among learners for recognitions.

The supportive VR technology, which provides an environment suited to constructivist learning, has been discussed thoroughly [29]. Winn suggests that the engagement of VR technology allows users to obtain varieties of knowledge-building experiences that are not available in the real-world size, transudations and reification, which are vital to learning [29]. Specifically, VR technology allows the radical changes of the relative size of a student and his VR objects. Via Winn's examples, a student could enter an atom to examine and adjust electrons in their orbital, thus altering the atom's valence and its affinity to form molecules. Alternately, a student could acquire the knowledge of the relative sizes and distances in the solar system by flying between planets. Transudations refer to the use of interface devices to present information that is not readily available to human senses [30]. However, our system contains three important essential learning features, real time graphic adjustment, transudations expression and that it is concrete. Additionally, in a VR learning environment, a student can be conscious of the size and color of the graphics.

Within the philosophy of constructivism, various pedagogical approaches can be taken by using distinct methods. The most popular of which is the guided-inquiry where, by performing tasks such as experiments, students are guided to uncover critical concepts independently. The second most common is the experiential approach. As all virtual worlds allow a user to experience a virtual situation, this term is applied herein to indicate a learning process that requires more than simple walkthroughs of expeditions through a virtual world. Additionally, educational VR applications, which are described as experiential, require further interaction and efforts that a student initiates.

Seymour [31] calls for further distinction of the constructivist views by focusing on the involvement of the student in the actual designing, constructing and erecting of "external" products or artifacts [32]. The idea behind using raw data, primary sources, physical, and interactive materials in a real-world environment is to help learners generate the abstractions that bind occurrences together. Researchers at MIT use the word "constructionism" to describe the knowledge construction process that arises from the physical creation of objects [32].

Constructivism has emerged in the last decade as an alternate pedagogy closely related to the advancement in educational technology. Interest in constructivism has blossomed considerably as conventional instruction and assessment techniques have been criticised for their inflexibility. There is a trend that educational scheme is turning into more flexible, open-ended, adaptive, and multi-dimensional instructional techniques as well as more qualitative, observation-based methods of evaluation. As a result, many educational technologists embrace constructivism and this is proven with the excess of multimedia and computer-based software spreading from the constructivist premises. In the course of adopting this constructivism, this proposed graphics system makes an ideal foundation to comply with this new theory in terms of establishing open, informal, and virtual learning environments [33].

8.0 THE STRUCTURE OF THE GRAPHICS SYSTEM

The purpose of this study is to develop an integrative graphics learning system in real time. Drawing complex curves and surfaces in a network browser instantaneously is an innovative technology. In this work, we have combined the Web with CAD to create a new approach to teaching curve and surface graphics. Fig. 6 and Fig. 7 respectively illustrate the system's interface flowchart and graphics algorithms.

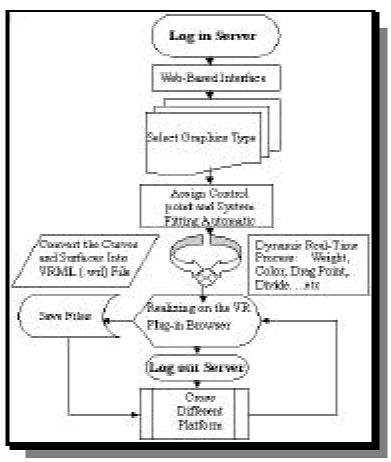


Fig. 6: System's operating process and interface

8.1 System's Operating Process and Interface

First, Learners register to use the system. They can login to the system anywhere, anytime. Students may choose any item on the interface by clicking on the hyperlink on the page. These choices include Bézier, B-spline and NURBS curves and surfaces. After learning to select the graphics type, students can assign control points to the sculpture graphics arbitrarily. The WebDeGrator system will fit these control points automatically and generate sculptured surfaces and curves according to the learners' directions. Students can learn to construct CAD-related knowledge and experiences through dynamic simulation and applications, such as dragging these control vertex points, adjusting the weight values, graphics rotation, …, etc

8.2 Graphics Algorithms

This work about the Graphics algorithms has three tiers: the first layers are fundamental geometry graphics algorithms, such as point, line plane circle, …., etc., the second layers are sculpture surfaces and curves, such as Bézier, B-spline and NURBS algorithms. The final layers are system-related CAD functions, such as drag control point, modify weight value, set degree value, …., etc., as shown in Fig. 7.

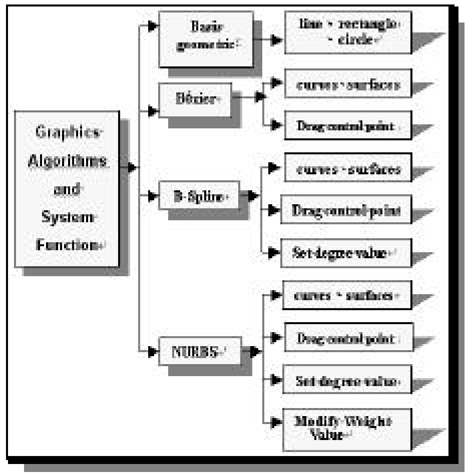


Fig. 7: Dendrogram depicts system's functionality and its graphics algorithms

9.0 CURVE MODELING AND SURFACES MODELING

This emerging field in constructivism has rapidly motivated researchers to utilise an effective tool for improving their working environment. Therefore, we have constructed a program package for modeling and analysing parametric curve to be named as CM ("Curves Modeling") method as shown in Fig. 8(a). It is written in OpenGL to consider not only 2D but also 3D curves as well. Three various methods are incorporated in CM at the first level in the menu. Considering all levels in the menu, there are ten methods or their corresponding modifications. In the interpolation methods, a curve passes through all control points. In the approximation methods, however, a curve passes only near the control points as shown in Fig. 8(b) [34, 35].

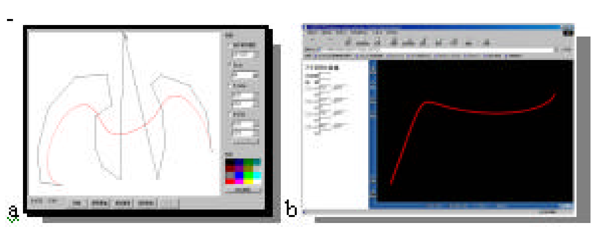


Fig. 8(a): The Curve modeling interface
Fig. 8(b): The Curve modeling of real-time simulations and adjustments

This study has also constructed a program package for modeling and analysing of parametric surface methods called SM ("Surfaces Modeling") as shown in Fig. 9(a). A surface is determined by an equation in parametrical form (parameters u and v). Of particular concern are u and v directions (parametrical view) or pertaining to direction X and direction Y, respectively (2D screen view). In the knot vectors for u and v (Uknot, Vknot), there are parametrical values u and v for patch boundaries as shown in Fig. 9(b) [34, 35].

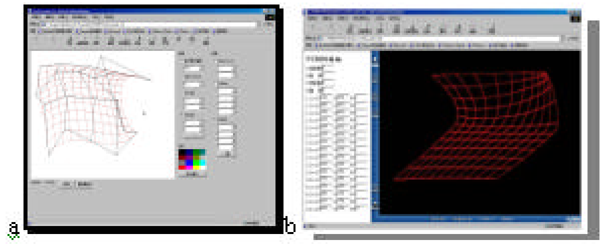


Fig. 9(a): The Surface Modeling interface
Fig. 9(b): The Surface Modeling real time simulations and adjustments

10.0 IMPLEMENTATION AND ILLUSTRATIVE EXAMPLE

Fig. 10 through Fig. 18(d) provide illustrative examples when implementing the **WebDeGrator (Web Design Graphics)** system. This study emphasises that this proposed new technology can be used to develop the following system **(Interactive Real-Time Computer Graphics System)** [36].

10.1 Brief Overview of the WebDeGrator

Fig. 10 is a brief overview of WebDeGrator. When the students login the learning system, they can learn and simulate related CAD knowledge and experiences through Web-Based learning pages. Interactive learning among students and system assistant is proceeding. When the learner adjusts or modifies the graphics in real time, the system assistant presents a real-time indication, and guides the learner towards his/her next accomplishment based on the learner's web portfolios. Finally, learners can save files or deliver their work anywhere and review other files for improving the design. As the *WebDeGrator* system supports operating systems, such as Windows and Linux, portability and cross platforms are facilitated.

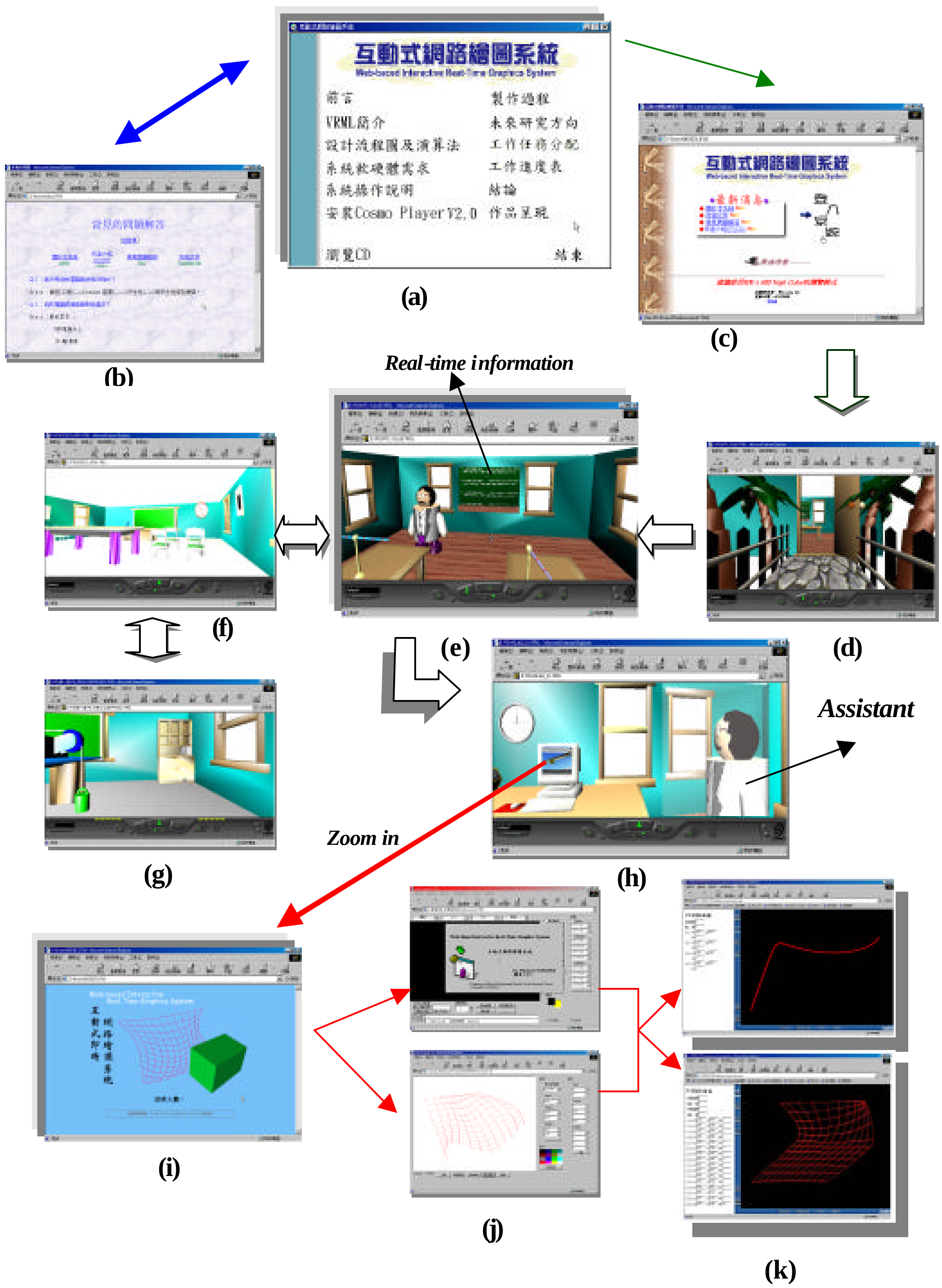


Fig. 10: (a) System auto run and main menu.
(b) Online documents and Q&A.
(c) Login Server.
(d) Enter 3D virtual world.
(e) Assistant.
(f),(g) The outlook of virtual class room.
(h) The entry of learning and designing.
(i) Interactive Real-Time Computer Graphics System.
(j) The WebDeGrator System.
(k) The Curve and surfaces modeling of real-time simulations and adjustments.

10.2 Some Exemplary Examples

Fig. 11 through Fig. 18 are some exemplary examples. VR technologies provide a unique method for enhancing user visualisation of complex three-dimensional graphics and environments. By experience and environmental interaction, users can more readily perceive the dimensional relationships of graphics typically portrayed through static multiview or pictorial representations. Fig. 11 through Fig. 15 are the results of real-time simulation, including setting or adjustment of the weight value (See Fig. 11(a) (b)); selecting a control point and degree in various forms (See Fig. 12(a) (b)); rotation of the triangle cone randomly (See Fig. 13(a) (b)); assigning the Control Points for NURBS curve (See Fig. 14(a) (b)) and NURBS surface automatic fitting (See Fig. 15(a) (b)). Fig. 16 and Fig. 17 are the applications which combine 3D VRML graphics and Database with a real-time 3D query interface, including a variety of queried merchandises (See Fig. 16(a) (b)); real-time dynamic view, and queried by variety index (See Fig. 17(a) (b)). Fig. 18(a) through Fig. 18(d) are related CAD application in education, training and business.

(a) (b)

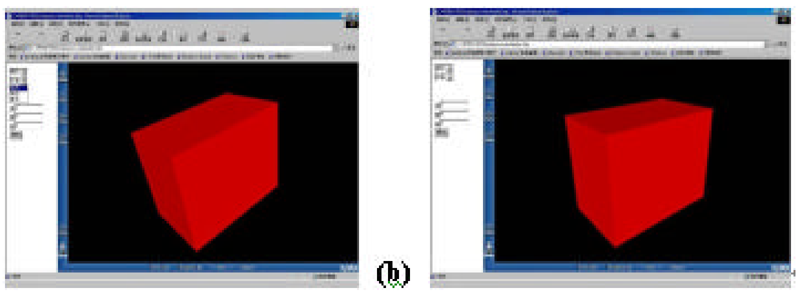


Fig.11 (a): Setting or adjustment of the weight value
Fig.11 (b): Real-time regular viewpoint by filling in left blanks

(a) (b)

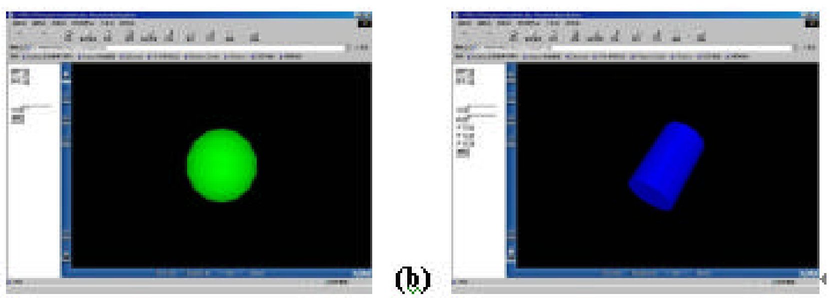


Fig. 12(a): Select a control point and degree in various forms
Fig. 12(b): Illustration of a cylinder solid

(a) (b)

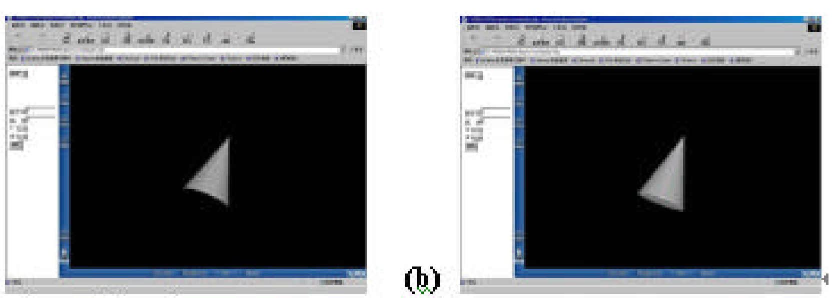


Fig.13 (a): Expression of triangle cone
Fig.13 (b): Rotation of the triangle cone in real time by dragging the Control Points

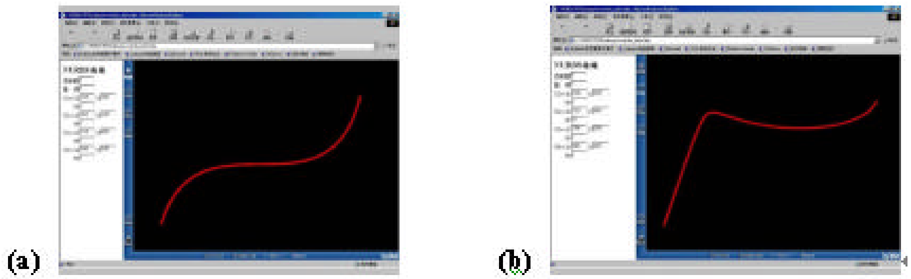


Fig. 14(a): Illustration of NURBS curve (Randomly Assign the Control Points and System Automatic Fitting)
Fig. 14(b): Real-time Local Modification (Real-time regular parameters by filling in left blanks)

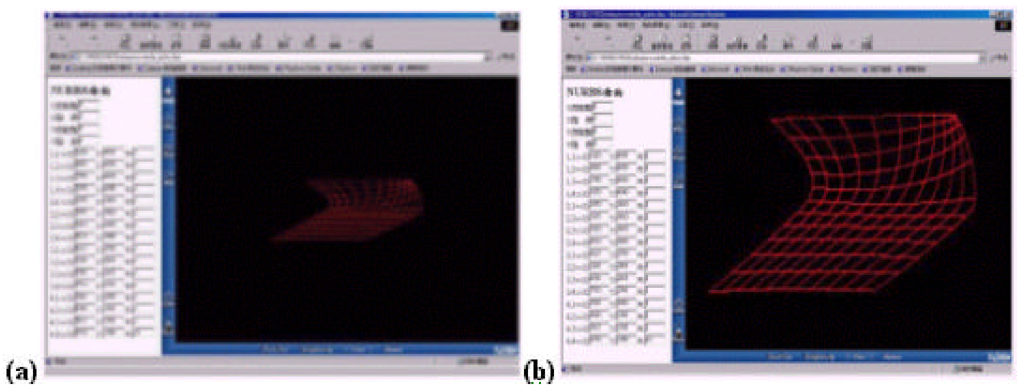


Fig. 15(a): Illustration of NURBS surface (Randomly Assign the Control Points and System Automatic Fitting)
Fig. 15(b): Real-time Local Modification (Real-time regular parameters by filling in left blanks)

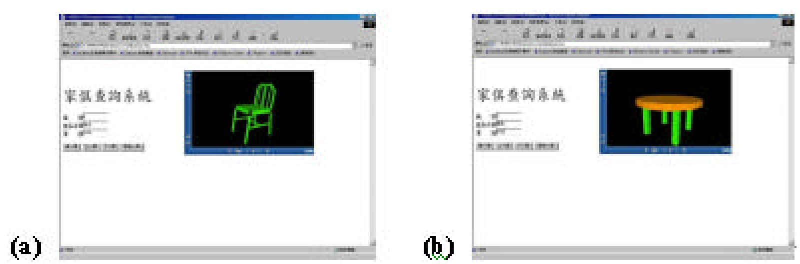


Fig. 16(a): Combine 3D VRML graphics and Database with a real-time 3D query interface
Fig. 16(b): A variety of queried merchandises

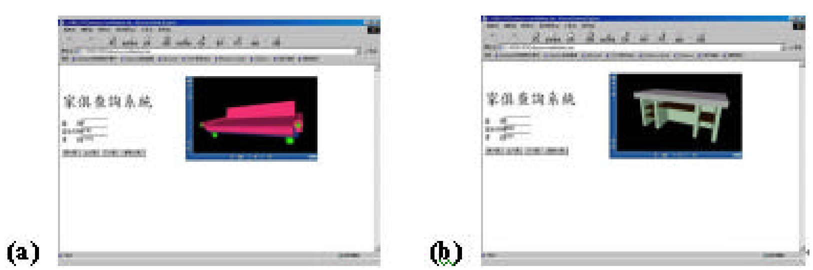


Fig. 17(a): Queried by variety index
Fig. 17(b): Real-time dynamic view by dragging this 3D modeling

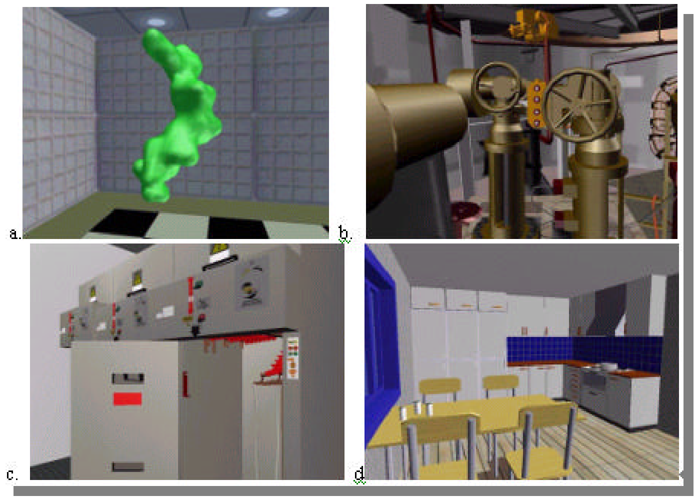
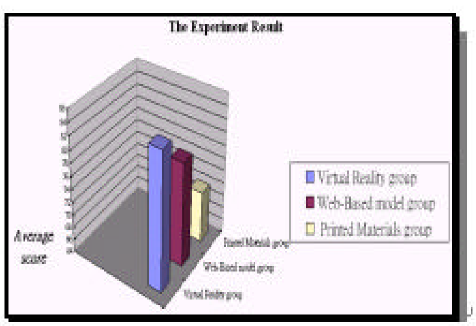


Fig. 18(a): Education - A molecule. (b): Training - Inside a nuclear power plant.
(c): Training - Inside a transformer room. (d): Business - A kitchen design [37]

11.0 EXPERIMENTAL RESULTS

This investigation tested the effectiveness of computer graphics learning between CAD and CAGD Students at National Central University of Taiwan who were enrolled in ACAD team. The team was divided into three groups: the virtual reality group used a virtual reality model of a computer graphics, the physical model group used a Web-based model computer graphics, and the printed materials group had a diagram of a computer graphics for examination. The three groups were given a pretest and a post-test with their scores compared to determine if the three groups significantly differed. While the groups were significantly different, the virtual reality group performance was the best; the Web-based model group was better than the printed materials group as shown in Fig. 19 [38].



Group	pre-test scores	post-test scores
Physical model group	62.350	71.040
Web-based model group	56.670	78.930
Virtual reality model group	58.190	84.150
Standard deviation value σ	2.940	6.600
Variation value	5.764	29.041

Fig. 19: System evaluation and experimental results [38]

12.0 CONCLUSION AND FUTURE WORK

This study has established a novel Web-based real-time graphics system. In summary, the proposed system has the following merits:

1. *Capability to develop an Integrated Graphics Learning System in real time.*
2. *Capability to share the resources in networks.*
3. *Capability to establish a computer network assisted learning system.*
4. *Capability to explore and compare these algorithms of the sculpture curves and surfaces.*

5. *Capability to integrate VRML with Web–based learning system and realises 3D graphics in the VR environment.*

The **WebDeGrator (Web Design Graphics)** system was designed to provide users and teachers with a convenient, easy and useful workspace in learning CAD. It provides a Web-based learning environment including web-browser and VR-browser. The capabilities for users is to walkthrough the 2D and 3D environments when simulating the designed curves and surfaces can increase the effectiveness of learning [39, 40].

An interesting area for future research is to investigate how to extend VR's learning systems, and how to convert the network database and learning system into an intelligent learning system that can record every user's data with regard to their learning condition and status.

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BIOGRAPHY

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