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Educational Online 3D Workshop Simulations

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Abstract.

This paper describes the stages in the development of an online 3D interactive virtual learning environment for use in art and design higher education. The 3D interactive environment enables users to experiment within virtual workshop and studio spaces independently or as multi-user groups. The environment will create opportunities for adding interactive 3D on-line teaching support materials, links to 'live' lectures and provides real-time distance communication learning and training experiences for students working out on industrial placement and internationally on franchise courses.

The intersection of play, pedagogy, and technology within the project, has been developed through the strategic use of 3D modeling, animation, and virtual 3D programming software. The research team has investigated and applied new ways of teaching, learning and creative thinking by using game structures and functionality as a framework. The conclusions discuss the value and potential benefits for introducing interactive game-style learning tutorials into new areas of education.

1. INTRODUCTION

The focus of the paper is on a research project to develop an online 3D virtual interactive workshop for use as a virtual learning support environment in the School of Art, Design and Architectural (SADA) at the University of Huddersfield. The design, development and functionality of interactive web based 3D environments, linked with the most effective ways to communicate, integrate and embed evolving CAD/CAM industry processes into art, design and technical workshop practices and other essential workshop health and safety support information have been investigated in this project.

The research project was funded by the University of Huddersfield teaching and learning research fund The initial stages of development are the interactive visualisation of 3D Computer Aided Manufacturing (CAM) operations, linked with 3D workshop health and safety support training and online 3D learning demonstration tools. The virtual workshop is just one area of development within a larger 3D University environment where different clusters are virtually connected together in order to integrate learning of different practices and technologies. Using 3D modelling software and interactive 3D game programming technologies, the team have also accurately modeled and simulated the workshop building which has been fitted with virtual furniture, engineering machinery, avatars and functionality. The buildings near to the workshop were also modelled including the Creative Arts Building (CAB).

1.1 CAD/CAM workshops in art, design and architecture

The recent investment by the School of Art, Design and Architectural (SADA) in laser cutting and 3D Rapid Prototyping (RP) machines has massively increased the volume of use by students. High quality, on demand, consistent technical support and learning skills development communication is now expected from the technical and academic staff. The 3D workshop has two 3D Stereo lithography printers, two laser cutters and a wide range of other cutting, moulding, manufacturing and finishing machinery purchased for use on product and transport design courses. The textile department has also recently purchased a soft material laser cutter for use with paper, fabrics, plastics and other flexible substrates. This laser cutter is often used in parallel with the output digital fabric printers, embroidery, knitting and weaving machines by textiles, surface design, crafts and fashion students to produce a diverse range of work.

An increasingly high volume of additional student and staff users from architecture, fine art, multimedia, interior design, communication arts (advertising, graphics & illustration) courses are entering the 3D and textiles workshops to locate these new technologies. Due to their lack of experience in technical workshops all new students must receive an induction. Regular technician demonstrations are used to support project academic delivery. Students are shown safe operational usage methods of 3D printing, laser cutting and other production machines in the SADA workshops. The technician-demonstrator staff offers a range of one to one and small group support in collaboration with academic delivery.

After being inducted, there is a constant flow of students asking technicians to laser cut diverse styles of designs onto a diverse range of material selections, this intensifies with project deadlines and annually towards graduate examination/exhibitions.

The digitally produced design files are usually not correctly prepared for cutting by students. The technicians must first check and clean, edit and process each student design before they can be sent to the laser cutter computer. Up to date monitoring and communication of health and safety information and repeat demonstrations are also required on a day to day frequency. These essential support and demonstration services are all being provided in very limited physical spaces to an increasing number of students with ever more diverse course project requirements.

Current teaching and learning practice within art and design education, includes many different academic and technical staff presenting technical input and output details on different modules and industry linked projects. Specific user guides, tutorials and manuals information are made available to support the learner, and can be accessed from the university intranet via SADA page links into the Blackboard VLE and to other school/course related links. Learning materials can also be accessed directly from lecturers in the studios who give demonstrations on large plasma screen. However, there is an ingrained reliance on low quality black and white photocopied handouts. Photocopied handouts are high cost, text heavy and offer limited interest for new learners in design to production learning translation. (Sheard, Ahmed 2007)

2. BACKGROUND

21st Century learners belong to the 'Generation Now' culture (Tresser, 2007); young people are actively engaged in play and are developing advanced communication skills that naturally equip them with the skills to be confidently active learners in a universal web based multi-dimensional society. The extensive globalization of the world's cultures, it could be argued, is evolving all cultures into alternative technological connected spaces that are functioning from non-sequential online web inter-dependant interaction. (Sheard, Ahmed 2007,Squire,2003)

The cultural engagement and interest in recreational and educational gaming has led to increased research into 3D gaming technology and engagement/learning theory, focusing on the effect of using games in practice, for training and to develop the structure of cooperation in game play situations. (Elliot, et al, 2002, Hoare, 2005, Octar, 2006) The serious implications of gaming in education are still relatively new, but the application potential is rapidly unfolding as demonstrated in this research. Balkin predicted this in 2004 and states that,

"...as multiplayer game platforms become increasingly powerful and lifelike, they will inevitably be used for more than storytelling and entertainment. In the future, virtual world's platforms will be adopted for commerce, for education, for professional, military, and vocational training, for medical consultation and psychotherapy, and even for social and economic experimentation to test how social norms develop. Although most virtual worlds today are currently an outgrowth of the gaming industry, they will become much more than that in time." (Balkin, 2004)

The applied use of 2D and 3D digital tools for manufacture can assist the learner in his/her thinking process from the original concept to the product. Designing is an iterative process. In traditional art and design studio culture, courses are orientated around practice, and focused within both independent and collaborative project based learning and teaching. Students experiment using a range of media and tools for the development of all projects. During this process the student is encouraged to acquire the non-sequential development of new skills to design and then produce art or product in all its varieties and forms.

CAD and CAM technologies are now used extensively in schools (GCSE/A/S level), colleges (BTEC foundation) and universities for learning in art, design, engineering and medical subjects. The majority of new learners are entering HE education skilled at interfacing multiple varieties of digital hardware devices and graphic software interfaces. The use of social online messaging is now culturally, socially and globally embedded and is mainly used by teens and early 20s. Adobe Creative Suite is extremely popular and extensively used outside the educational environment by school, college and university students for independent editing, experimentation and communication of images.

3. 3D VIRTUAL ART & DESIGN PROJECT

The main objective of the project was to build a 3D virtual workshop learning environment that can be accessed online. Using 3D modeling software and interactive 3D game programming technologies the workshop building has been accurately modeled and simulated. See Figure1:

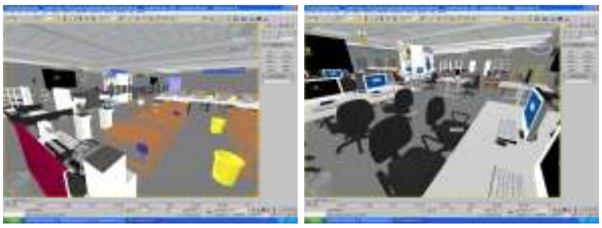

Figure 1. 3D Modelling of studio and workshop with machinery, furniture and computers

The methods applied for building and developing virtual spaces within the 3D environment for modeling, character styling and functionality of objects are as follows:

- Research, planning and design
- Concept layout: ideas development, illustration and story boards
- 3D modeling of the workshop physical spaces
- Creation of textures, lighting, sound, video
- Simulation of laser cutting process, and other CAD/CAM processes and machinery
- Health and Safety simulations for all potential hazardous events.
- Simulation of stereolithography machine
- Programming, testing and evaluation with users in education.

3.1 Development of workshop and studio spaces

This section describes the developing stages of the project. The research project team is made up of three undergraduate 3D; product and transport students, a postgraduate MA 3D Design student and two academics from the department of architecture and department of design. The year 2 undergraduate students were selected for their experience in 3D software. The MA 3D student was selected to solve transferring issues with basic interaction. The buildings, interior details and all machines were photographed to use as templates for creating accurate 3D models. The product design student used Solidworks to model all machines and the furniture. The transport design students used 3D Studio Max, Alias Design Studio to model the workshop building (exterior and interior fittings) added textures, and lighting. 3D animations of workshop and studio spaces (Doherty, Smith, 2008) were created to visualise first stage modelling and to evaluate the next stage before using 3D interactive programming software (Fig 2).

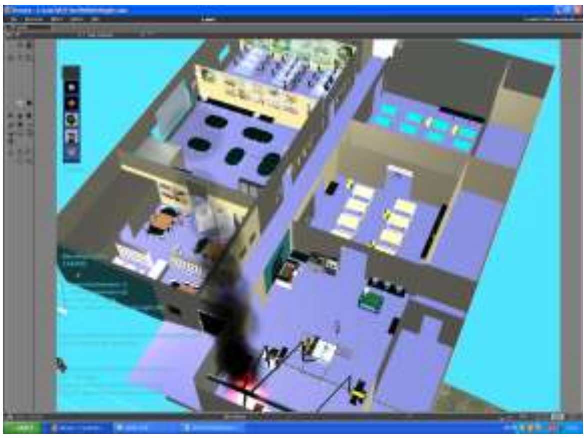

Fig 2 Workshop Building

The team used the 2D technical architectural plans which were used by students to model 1:1 scale of the CAB building and the campus. See Fig 3

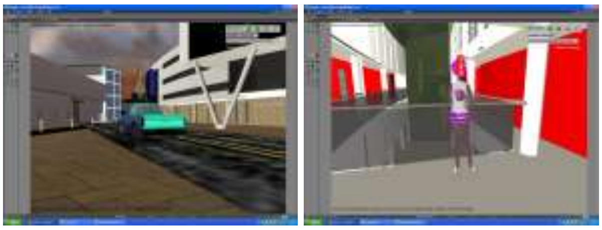

Fig 3: CAB building

The 3D models created in different packages were imported into 3D Studio Max. As these files consist of a high number of polygons files were merged and optimized. Pivot points for all the moving and rotating objects in the environment, such as doors were set in the exact hinge position. The next process was texturing and each image was optimised, cropped and cleaned up using Adobe Photoshop software.

Fig 4. Use of Characters / Avatars in the environment

The interactive 3D programming software used in this research is Virtools which includes a plug in for exporting 3D Studio Max 3D scenes to Virtools. This process was time heavy as material and lighting conditions used in 3D studio Max are not supported in Virtools. The tens of thousands of surfaces for all inside and outside surfaces need to be well organised, checked and adjusted for accuracy before any of the interactive programming commences.

3.2 Programming:

Virtools software was used to programme realistic simulations. When programming is added 3D objects interact together with associated behaviors. The team decided to use Virtools because of the following reasons:

- The team consists of academics and students from art and design backgrounds so Visual Scripting was essential for ease of use. If needed Virtools Scripting Language, C++ is available but not used.

- The following modules in Virtools were used to add interactivity: Behaviour library, Physics library, Multiuser functionality, web export functionalityr, VR Library and Publisher.

- Easy use of characters and their operation (see Fig.4)

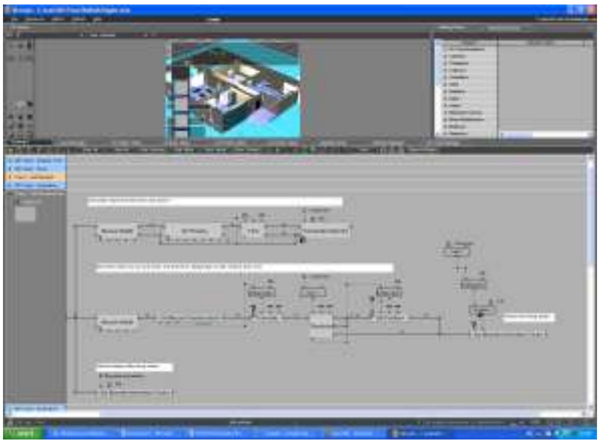

Fig 5 Virtools Programming

In Virtools, initially doors were programmed to open and close if a character is within a certain proximity (Fig 5). Number of characters were included and programmed for walk, run, turn, crawl etc. Walls were programmed as solid so characters could only go through the doors. Other characters were pre-programmed to walk. Floors and collision detection were also added. (Fig 6)

Fig 6 Character programmed to interact

3.3 Machine simulations.

In the workshop selected machines were simulated such as a lathe. In order to operate the lathe or other machines a user is asked by text command shown on the screen, if they are wearing protective goggles which are available on the wall. If they have selected the goggles from this location, the Lathe can then be activated by clicking on the red lever shown in Fig.7. The machining process and the machine parts are then explained using text and machine sounds. On activation the chuck rotates with a simultaneous machining sounds. The tailstock, carriage and saddle have all been programmed to move along the relevant axis direction when activated.

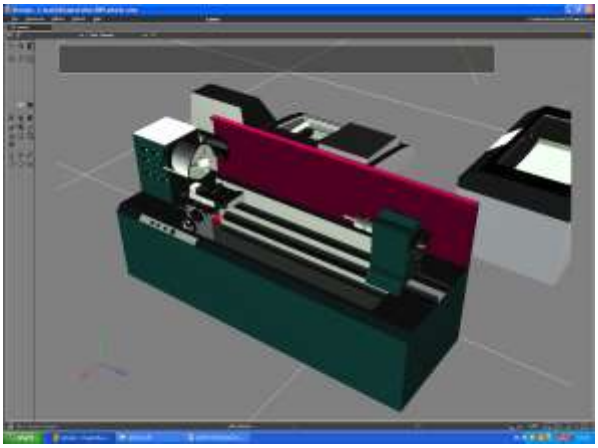

Fig 7 Lathe Simulations

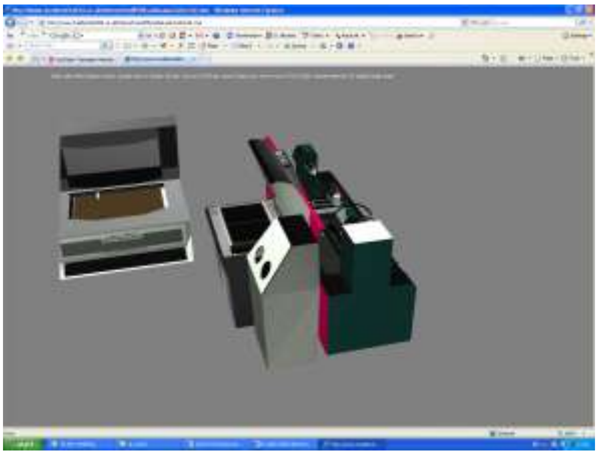

Fig 8 Laser Cutter Simulations

3.4 Laser Cutting simulations:

The laser cutting machine simulations shown in Fig 8. have been created to incorporate a integrated online real life sample library database. A library of different materials as a reference has also been identified for including in the virtual environment. This initial research has produced a range of soft materials and hard materials for example: crimpline, polyester and fiber glass, mats of cork, silicon, latex, solid rubber, cellular rubber, foam rubber, acrylic sheets, polypropylene, macrolon, epoxy resin and polyester resin, teflon and polyamide plastic which could be cut with a selection of variable parameters.

This virtual machine has been programmed with information on laser settings (power, speed and resolution) so only available and safe materials can be selected for real life cutting. The data gathered and included in the machine simulation will enable students to test whether the intended cutting process is possible without taking technical team time.

ZCorp Rapid Prototyping (RP) machine was also simulated to demonstrate the RP process, this informs the user of sizes, material limitations, cost, other advantages and disadvantages compared to other 3D RP machines available in the workshop.

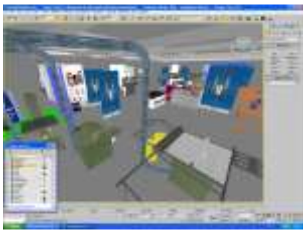

Fig 9 RP Machine Simulation

Fig 10 RP Machine Operation

RP or Stereo Lithography is a process that prints many layers of powder or resin to build a complete physical model from a 3D CAD model. Figure 10 shows the virtual production of a 3D model being built layer by layer. In this simulation users can move the camera mode using assigned keyboard commands to look around and zoom in out. The user selects the handle on the top door of the RP machine, and the door can be opened. Users are instructed to move the mouse over the actively programmed areas to encourage experimental testing and learning of possible functionality and materials usage. Instructions for use are scrolled onto the screen in text format and exact operational sound is played when operating.

3.5 Health and safety simulations:

To simulate health and safety procedures the following simulations were added into the virtual 3D workshop environment:

Fire:

- Fire randomly starts in any location especially in the workshops. Procedures using text and sound for students and staff to use for induction and repeat learning have been programmed.

- Students are required to leave the building using their avatar and go to approved meeting location. These directions are simulated so that the fire collection point location has been understood safely without cost eg. Fire service callout.

- Allocated health and safety staff are required to immediately dress in Luminous safety jackets and check each studio and room and direct students to the nearest exit to meet at the fire collection point away from the workshop.

- The staff needs to visually check the doors during the fire alarms and nobody goes in or out until fire service arrives.

Accident:

Students while using the machines can easily injure their body, and the programmed procedure included in the workshop simulation is:

- Find the nearest health and safety person, if they are not available the user's avatar is directed to the next available options.

- If the accident is very serious, the simulation asks questions about who will be the next contact persons and offers other information about contacting an ambulance and the hospital location.

- Other health and safety issues, basic health and safety guides. Such as goggles, gloves, hair and clothing and bags guidelines.

The objective for developing the 3D simulation is that students can pre-learn or re-learn to use the actual machine in the virtual workshop. The user/learner can see how machinery operates, learn about the limitations, advantages other real world processes in advance independently. If the students have were absent from the technician's introductory demonstration or had difficulties with learning then they can revisit and learn in their own time.

4. CONCLUSION

Based on the initial research and developmental work in the virtual environment, we believe that this project has the potential to extend far beyond the 'traditional' glass, bricks and mortar learning and teaching experience for everyone; students, and staff at all levels within the University of Huddersfield. Workshop, CAB and other university buildings have been developed that are exactly to scale which provides a simulated location campus arrangement for users in the Virtual environment to navigate around and to ensure that users are able to locate themselves and easily find tutors, meeting rooms and workshops.

Developing and building interactive 3D environments, is a time consuming process which requires a number of dedicated staff with different skills. During the development process the actual environments changed several times, new alterations were carried out and some of the buildings are used for different purposes. Updating simulations in line with real world changes should be carefully planned. The team believes that 3D virtual environments are not best used for duplicating exactly everything. In institutions and companies constantly changing and evolving situations such as finding staff and office locations in the campus are difficult to manage. Although as 3D virtual environments and the tools to build them are increasingly adopted in the future of the internet this type of interactivity may be included.

Online 3D multi user worlds such Secondlife, There, Playstation's Home, HiPiHi and Sun's wonderland etc. are social and recreational networking spaces and have millions of registered users. Currently many universities and brands have a presence in these worlds. However this pioneering work has limitations as often pre-programmed simulations can only be permitted or developed by the owners of the virtual world. A high level of programming skill is required to create specific customised interaction or by employing the services of 3D virtual world development consultants. Modelling in these worlds is generally pre-defined by the interface tools and basic primitives.

There are a large number of design, engineering, multi-media etc. graduates whose skills in 3D modelling, rendering and animation. These 3D designers would be interested in transferring their concepts and high quality models to these online 3D virtual worlds without learning or employing game programmers.

In the future we predict any user will be able to exhibit their 3D concepts with interaction in online spaces and in 3D multi user worlds. The developers of 3D multi user worlds need to make accessible open import functionality within their software. Programming should be simple and visual rather than use hard core or unusual programming script

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