Web based Interactive 3D Learning Objects for Learning Management Systems

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ABSTRACT

In this paper, we present an approach to create and integrate interactive 3D learning objects of high quality for higher education into a learning management system. The use of these resources allows to visualize topics, such as electro-technical and physical processes in the interior of complex devices. This paper addresses the challenge of combining rich interactivity and adequate realism with 3D exercise material for distance e-learning.

Keywords: e-learning, educational material, 3D learning objects, 3D animation, engineering education, virtual lab, virtual reality

1. INTRODUCTION

Traditional e-learning resources in common learning management systems (LMS) for semiconductor and microsystems technology illustrate the visual material - on the one hand by using interactive, schematic and plane shapes or on the other hand with high-quality movies and pre-rendered animations. Usually, these animations do not provide interactivity with the camera view, the scene or the objects within the scene. There is an imbalance between realism and sufficient interactivity concerning both types of these representations. In the area of semiconductor and microsystems technology, this leads to a growing challenge concerning how to communicate linked subjects like electro-technical and physical processes in devices used in laboratories. For example, photographs or videos of a fully mounted X-ray photoelectron spectroscopy device (XPS-device) provide only few details and underlying fundamentals. The student may not see the device because of extensive cabling and additional technical elements (see Figure 1).

2. THREE-DIMENSIONAL LEARNING OBJECTS

The demand of material for e-learning courses that combines interactivity and realism with didactic abstraction leads to the creation of 3D learning objects (3DLO). A 3DLO, defined as a special case of a learning object [13], represents an interactive three-dimensional digital resource that can be reused to mediate learning and be integrated into learning management systems or virtual learning environments [13]. It contains, among others, 3D instructional material, simulation information, metadata as well as rights and permissions [15]. The 3DLO can contain an interface for the interactivity, which may be independent from the LMS.
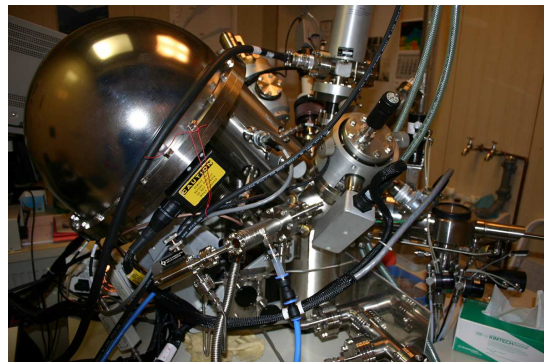

Figure 1. An XPS device in a laboratory setting.

The use of 3DLO within a LMS leads to several advantages. The first advantage can be divided into two parts. On the one hand, complex devices can be visually simplified by software in order to minimize the cognitive load. On the other hand, using virtual reality allows to visualize hidden and invisible areas, such as the inside of the devices. The second advantage is providing unlimited access to a system through virtualization. Systems that are locked for students because of security reasons or on-going research can be made virtually accessible. This generates a win-win situation not only for the student but also for the research staff. Getting the opportunity to interact with a virtual system can be more motivating and fascinating than studying this system with common static or textual learning material. For the research staff, the laboratory may be used for extensive long-term research without interruptions. An additional benefit of using 3DLO may be reached by reducing the risk of malfunctions. Critical and necessary parts can be demonstrated or additionally accentuated.

3. RELATED WORK

The use of 3DLO has been widely proposed for medical education as an approach to enhance the learning of complex aspects as well as the individual's motivation for learning. Three types of 3D learning objects can be identified. The first type is integrated in offline learning settings, such as installed applications, or distributed media. Examples can be found in the simulation of medical devices [11], [12] or in the area of semiconductor and microsystem technology [1], [16], [18]. Second, 3D learning objects are integrated into virtual 3D environments (or virtual worlds), such as Second Life or Wonderland [2], [15]. In order to use these virtual worlds, the user has to install special applications for access and visualization. The navigation, cooperation and communication with other users and interaction with elements or 3DLO of this type are performed by a virtual representation of the user within the 3D environment. Courses using 3DLO or actions with 3DLO generated by other users can be performed without the participation of a single user [6]. This means that a single user can miss some results. The third type of 3D learning objects covers single resources that are embedded into courses of common 2D learning management systems or regular e-learning sources. To visualize this type of 3DLO, special plug-ins or players are required [9]. The representation of chemical and physical fundamentals [7], [14] and the simulation of simple electric motors [4] are examples for embedded 3DLO.

E-learning in the area of semiconductor and microsystems technology challenges the student's power of abstraction and imagination. The student needs to understand the electro-technical and physical processes in the interior of a device as well as the setting of dependent systems of an entire laboratory. Visualization of invisible processes in the interior has been shown necessary for a deeper understanding of the subject by the student in the work of [12]. A broad discussion and examples of the use and the effects of 3D exercise material can be found in the field of medical education and training for special medical devices [10], [11]. Examples of using virtual interactive representations for physical processes have been given by [7], [14].

These discussions result in the proposal of four requirements for 3D in e-learning and special for 3D learning objects:

- Respect the knowledge base and the spatial perception of the student [3]
- Reduce the cognitive load in comprehension to comparable non-interactive learning material [10]
- Find the subject-specific balance between a realistic visualization and the activation of intellectual abilities [5]
- Create an additional value for the student and address the individual curiosity for exploration [19].

4. METHOD

For our approach, we use the 3D content developed by the enterprise 3D:it in cooperation with the group of Johann Bartha from the Institute of Semiconductor and Microsystems Technology (IHM) at TU Dresden. The IHM provides images, videos and consultations and defines areas in the model, which are of special interest for the lecture. After modeling, the 3D content is compressed and encrypted to prevent access to the sources. The Apache ANT step compiles and builds automatically an application for the use in lectures or seminars and applets for courses in LMS or websites. The figure below illustrates this process chain.
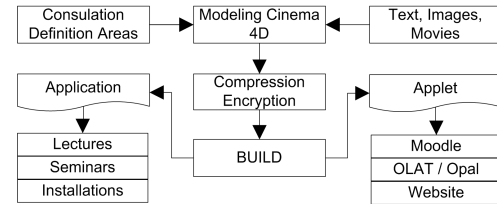

Figure 2. Process chain for creating 3DLO.

The exercise material is embedded in common learning material within the web based curriculum of micro electronics, which is delivered by the LMS OPAL. OPAL is provided by the "BPS Bildungsportal Sachsen GmbH" for all higher education institutions in the German federal state of Saxony and is based on the open source LMS OLAT of the University of Zurich. The OPAL LMS provides different tools for corporation, coordination and communication.

5. PROTOTYPE

For the implementation of the prototype we decided to use a solution based on the Java programming language. Java is open source, platform independent and supports an easy integration as applet into the OPAL LMS [8]. Java provides a simple interface and further libraries for using OpenGL in Java applets. The support of OpenGL is recommended for this approach to achieve platform independent graphic hardware acceleration for high performance visualization of 3D material. The prototype loads and handles the 3D models, which are contributed by the IHM group. The applet provides free navigation in X-,Y- and Z-direction to explore the visualization of the 3D learning object at run time. The model can be rotated, moved and zoomed. We use the "controlP5 GUI and controller library" in order to provide a graphical user interface in addition to the free navigation [17].
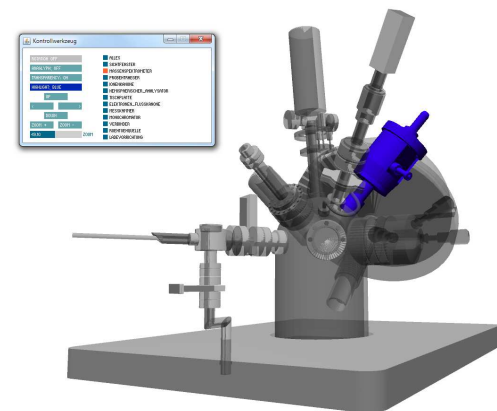

Figure 3. The current prototype images an XPS device with one highlighted area of interest.

The use of the "controlP5 GUI" instead of Java Swing or AWT is necessary to avoid problems with simultaneous OpenGL rendering. Via pre-defined views, special parts of the model can be focused and highlighted by the user (see Figure 3). The prototype allows to visualize single parts of the whole device

(see Figure 4). To create an additional value for the student and to raise the individual curiosity, the view of the prototype can be switched to a transparent mode and a stereoscopic view via anaglyph technique to improve depth perception of the complex system. The standard view shows the model without any wiring, cabling or additional parts.
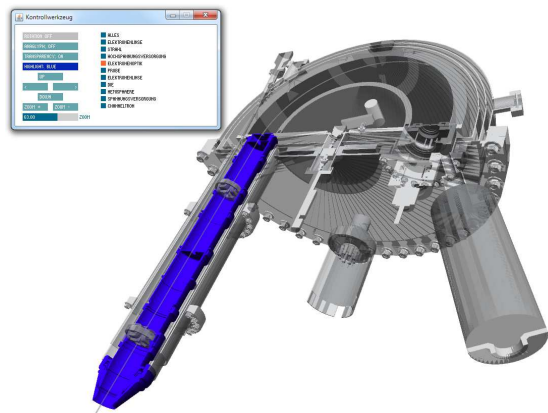

Figure 4. The prototype imaging a hemispherical analyzer of an XPS device with one highlighted area of interest.

This aims at reducing the cognitive load by separating necessary from less important parts of the system as proposed in the requirements.

6. CONCLUSIONS AND FUTURE WORK

This paper presented an approach to embed interactive 3D learning objects into a web based curriculum in the field of semiconductor and microsystems technology. Future research will extend the prototype by the integration of simulation components for the use of exercises. This interface will simulate the virtual system and transfer the results of the modifications for further discussion into real lectures. Furthermore, we will perform a user study to evaluate the effects of virtual interactive 3D learning objects specially for independent learning and auto-motivation. This will allow a cost-benefit analysis with regard to the initial costs for developing such exercise material. The goal of our research is to effectively integrate further interactive 3D content into distance learning and teaching.

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REFERENCES

[1]   Adamo-Villani, N.; Richardson, J.; Carpenter, E.; Moore, G. (2006), "A Photorealistic 3D Virtual Laboratory for Undergraduate Instruction in Microcontroller Technology", **SIGGRAPH 2006**, Boston, ACM, 2006, 21.

[2]   Bouras, C.; Philopoulos, A.; Tsiatsos, T. (2001), "E-Learning through Distributed Virtual Environments", **Journal of Network a. Computer Applications**, 24:3, pp. 175-199.

[3]   Chittaro, L.; Ranon, R. (2007). "Web 3D Technologies in Learning, Education and Training: Motivations, Issues, Opportunities", **Computers & Education**, 49:1, pp. 3-18.

[4]   Cui, J. (2008), „Entwicklung eines interaktiven virtuellen 3D-Modells eines Asynchronmotors", **12. Workshop „Multimedia in Bildung und Wirtschaft"**, Ilmenau, Germany, TU Ilmenau, 2008, pp. 37-44.

[5]   Dalgarno, B.; Bishop, A. G.; Adlong, W.; Bedgood Jr, D. R. (2009), "Effectiveness of a Virtual Laboratory as a preparatory resource for Distance Education chemistry students", **Computers & Education**, 53:3, pp. 853-865.

[6]   de Freitas, S. (2008). "Serious Virtual Worlds report", **JISC**, http://www.jisc.ac.uk/publications/reports/2008/seriousvirtualworldsreport.aspx (02. June 2010).

[7]   Engel, T.; Hemmer, M. C.; Hofmann, A.; Schunk, A.; Spycher, S.; Gasteiger, J. (2000), "A New Quality of a Chemical Education System based on the WorldWideWeb", **Terena Networking Conference 2000 "Pioneering Tomorrow's Internet"**, Lisboa, Portugal, 2000,

[8]   Hesse, S.; Spehr, M.; Gumhold, S. (2010), „Erstellung und interaktive, webbasierte Visualisierung von 3D-Lernmaterialien", **8. Workshop on e-Learning**, (15. Sep 2010, Zittau, Germany), Hochschule Zittau/Görlitz, 2010, pp. 191-200.

[9]   Hesse, S.; Gumhold, S. (2010), "Production and Integration of Web Based Interactive 3D Instruction Material in the Field of Micro Electronics", **2. Symposium E-Learning an Hochschulen. Dresden**, Germany.

[10] Holzinger, A.; Kickmeier-Rust, M.; Albert, D. (2008), „Dynamic Media in Computer Science Education; Content Complexity and Learning Performance: Is Less More?", **Educational Technology and Society**, 11:1, pp. 279-290.

[11] John, N. W. (2007), "The Impact of Web3D Technologies on Medical Education and Training", **Computers & Education**, 49:1, pp. 19-31.

[12] Jung, Y.; Recker, R.; Olbrich, M.; Bockholt, U. (2008), "Using X3D for Medical Training Simulations", **WEB3D 08**. Los Angeles, ACM, N.Y., 2008, pp. 43-51

[13] Metros, S. E.; Bennet, K. (2002), "Learning Objects in Higher Education", **ECAR Research Bulletin, EDUCAUSE Center for Applied Research**, Nr.19 (2002). Boulder, Colorado, 2002.

[14] Mzoughi, T.; Herring, S. D.; Foley, J. T.; Morris, M. J.; Gilbert, P. J. (2007), "WebTOP: A 3D Interactive System for Teaching and Learning Optics", **Computers & Education**, 49:1, pp. 110-129.

[15] Paredes, R.; Sanchez, J. A.; Rojas, L.; Strazzulla, D.; Martinez-Teutle, R. (2009), "Interacting with 3D Learning Objects", **Web Congress 2009. LE-WEB '09,** 2009, pp. 165-168.

[16] Salazar, E. A.; Macías, M. E. (2009). "Virtual 3D Controllable Machine Models for Implementation of Automations Laboratories", **FIE 2009**, San Antonio, Texas, IEEE Press, 2009, pp. 701-705.

[17] Schlegel, A. (2010), "controlP5: A gui library for processing", http://www.sojamo.de/libraries/controlP5/. (14. June 2010).

[18] VijayKumar, V.; Kansari, N.; Groves, J. F.; Bean, J. C. (2002), "Creation of web-based interactive virtual experiments on microelectronics for early engineering students", **FIE 2002**, Boston, IEEE, 2002, pp. 6-9.

[19] Webster, J.; Trevino, L. K.; Ryan, L. (1993), "The Dimensionality and Correlates of Flow in Human-Computer Interactions", **Computers in Human Behavior**, 9:4, pp. 411-426.