Web-based 3D Online Crown Preparation Course for Dental Students

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ABSTRACT

Despite enthusiasm for the educational potential of the World Wide Web, few dental educators use the new opportunities offered by this medium beyond the presentation of textual information. Based on this observation, we have decided to design our own interactive Web-based 3D crown preparation course. The course objective is to provide dental students with fundamental didactic and technical knowledge to begin preclinical skill development for full crown preparations. The course incorporates a variety of interactive features including images which allow students to examine the dimensions and contours of the burs in comparison to the dimensions and the shape of the crown preparation. QuickDraw 3D allows the direct manipulation of 3D graphical models by the users.

This paper will relate experiences in the development and implementation of a Web-based course with 3D direct manipulation. An initial evaluation of the development process offers directions for further development, necessary technical support, and faculty and student preparation.

INTRODUCTION

A rapidly increasing number of continuing medical and dental education courses is available on the Internet[1,2,3,4,5].

Currently, Temple University School of Dentistry (TUSoD) integrates several of such Web-based resources into the school's intranet to enhance the opportunities for teaching and patient treatment, e.g. the Pulp Therapy Chapter of the Atlas of Pediatric Dentistry[6] and Lexi-Comp's Clinical Reference Library™ [7].

While there are more online courses offered for medicine than for dentistry, we were able to locate 157 online dental courses offered by 32 providers in an earlier study by Schleyer. The result of this study indicated that the quality and length of the currently offered courses vary significantly. For instance, most courses scored very low on a preliminary quality index for educational software[8]. Despite enthusiasm for the educational potential of the World Wide Web, empirical evidence from this study suggests that only a few dental educators use the new opportunities offered by this medium beyond the presentation of textual information with incorporated images.

Furthermore, we examined available anatomy Web sites for content to support the process of learning crown preparations. While there are excellent anatomy courses available via the Web[9,10], none of them offered enough detailed information related to human teeth.

These investigations about existing dental and anatomy online resources indicated that we had to design our own interactive 3D crown preparation course.

METHOD

In order to design an online tool to teach dental students how to prepare anterior teeth for porcelain fused to metal crowns, we informally surveyed prosthodontics instructors in our school. Their major requirements for a crown preparation course were

- detailed, three-dimensional models of the tooth in various stages of completion,
- the ability to compare models of procedural steps with the actual technique of producing that step (on-demand video for each step),
- the ability to compare and evaluate dental bur dimensions to tooth dimensions and contours, and to actually measure and focus in on bur dimensions so that the student will appreciate the bur dimensions and shapes relative to the procedural tasks, and
- the ability to easily move from step to step, in any order desired.

The main objective of a crown preparation course is to provide foundation knowledge for the student to begin preclinical skill development for full crown preparations. This foundation knowledge and successive skill development are necessary to begin the clinical phase of learning, the objective of which is to become competent in full crown preparation clinically.

Temple University School of Dentistry's (TUSoD) strategic computing plan requires that every new application has to be tightly integrated into our existing intranet[11]. Thus, only a Web-based application could be used for such a teaching tool.

Resource allocation

Budget constraints and a difficult situation on the labor market for information technology (IT) did not allow us to develop an entirely proprietary technology to reach our goals. In addition, it was planned that the new course shall function as a catalyst for further developments of highly interactive 3D direct manipulation courses covering various aspects of clinical dentistry. Thus, we focused our investigation on existing technological solutions, off-the-shelf 3D tooth models, and easy-to-use editing tools. The development team was led by one faculty member of the school's Department of Dental Informatics. All content aspects were guided by two faculty members of the school's Department of Restorative Dentistry. Development and production was handled by an intern student from the German University of Applied Sciences, Dresden, who worked at TUSoD for 6 months.

Technology

The development process started with a thorough evaluation of existing technological solutions for 3D presentation and their technical feasibility under the given constraints. Four main areas of decision were identified:

- 3D tooth models
- development software
- delivery through the Web
- tracking of individual access and progress

From a developer's point of view, such a highly specialized course requires a substantial amount of programming. Because of the given constraints, we mainly focused on the use of readily available technologies and off-the-shelf 3D tooth models.

Table 1 shows the chosen technology based on the given criteria:

- budget
- technical feasibility
- Web-based delivery
- high quality graphical display of teeth
- modifiable 3D teeth models
- integration of video clips
- interactivity in terms of direct manipulation

Table 1: Technology used to build 3D Course

Name	Purpose	Price*
Macromedia Authorware Attain, v. 5.1	course editing	$687.00
Newtek Lightwave, v. 5.0	3D model editing	$742.00
Macromedia Flash, v. 4.0	2D animation	$97.00
Adobe Photoshop, v. 5.5	picture and icon editing	$237.00
Adobe Premiere, v. 5.1	video capturing and editing	$258.00
Allaire Homesite, v. 4.0	HTML and Perl editing	$89.00
Complete Adult Teeth Model	3D tooth models	$495.00
Perl, v. 5.005_03	interpreting scripts for database connection	free
Authorware Full Web Player, v. 5.1	Web browser plug-in for the course	free
QuickDraw 3D Viewer, v. 1.5.3	display QuickDraw3D files	free
Windows Media Player, v. 6.0	display mpeg video clips	free

* educational version

Infrastructure

During the last few years, TUSoD has allocated substantial resources to build a its IT infrastructure: (1) *hardware*, *software* (2) *faculty training*, (3) *support and custom application*. All faculty have their own networked Windows NT workstations on which they were trained to use MS-Office applications, E-Mail and Internet/intranet resources. A Web-based clinical information system which is used by all students and faculty is based on an Oracle 8 database[12]. The use of a high-speed Web server to host the school's intranet provides sufficient storage for newly developed resources. Freshmen students complete the required course "Introduction to Computing" which equips them with the necessary computer literacy to use online resources efficiently[13].

Development

The six-month course creation included all steps of a software development life cycle[14].

System Planning: The project team interviewed faculty who teach crown preparation and informally surveyed students to develop the specifications.

Technical Design: After analyzing the results of the interviews and reviewing the given constraints, the team decided on the technology to be used (see Table 1).

Construction and Testing: The construction process was characterized by a substantial amount of trouble shooting mainly because of incompatibilities between different 3D formats and version incompatibilities between the software packages.

Integration: The course editing software, Authorware, per default uses an MS-Access database. However, the goal was to authenticate against our existing user database, Oracle 8. While this was

advertised as a trivial exchange of an ODBC driver, in reality the connectivity between Authorware and Oracle 8 could only be established using CGI-scripts. The database is used to store the participants' progress and their last accessed page to allow them to re-enter the course at the same page they left.

Testing: Extensive pilot testing on one of the school's prototype servers enabled us to fine-tune the application.

Documentation: A variety of programmer manuals and technical notes were created to facilitate further course developments using the same or similar technologies.

Training: Training was provided to all faculty who teach prosthodontics and are likely to refer to the course during their classroom lectures or their clinical teaching. When students and faculty access the school's intranet remotely, online help resources provide sufficient help on how to install the necessary Web browser plug-ins for all operating systems and browsers.

Support: The school's support staff was trained by members of the development team on how to install the necessary Web browser plug-ins using the remote installation capabilities via TUSoD's network (Timbuktu Pro®). In addition, all publicly available workstations inside the school were upgraded accordingly.

RESULT

The final course incorporates a variety of interactive features and allows individual tracking of the users' access. All initial requirements which were stated by the prosthodontics faculty and students were fulfilled. After a login using our existing user database, the course provides various interactive tools to teach full crown preparation.

Figure 1 showcases how students can evaluate dental bur dimensions in comparison to tooth dimensions and contours. This feature addresses the educators' requirement to allow students to measure and focus in on bur dimensions and shapes relative to the procedural tasks.

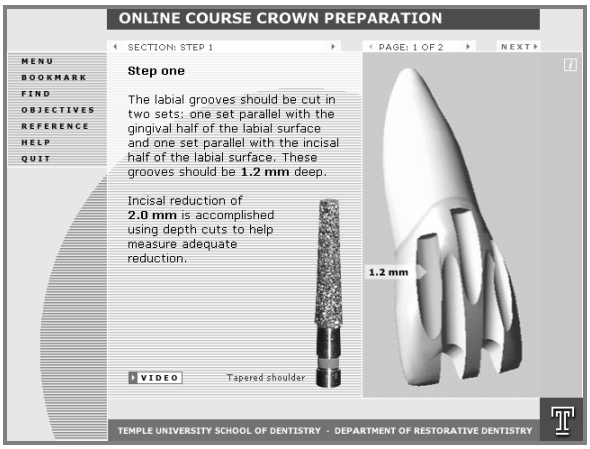

Figure 1: Dimension and contour of bur in comparison to the shape of the cut.

In addition, students can actively measure tooth dimensions in comparison to bur dimension by using interactive rulers (see Figure 2).

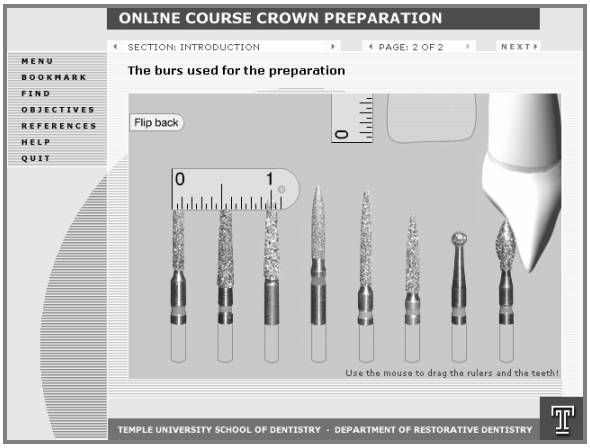

Figure 2: Interactive ruler for dimension measurement of bur and tooth.

Figure 3 shows a 3D model of a tooth at one stage of the crown preparation. Direct manipulation via the mouse allows users to see the model from any viewpoint and to magnify the model. The use of QuickDraw 3D accomplishes the educators' requirement for three-dimensional models of the tooth in various stages of completion.

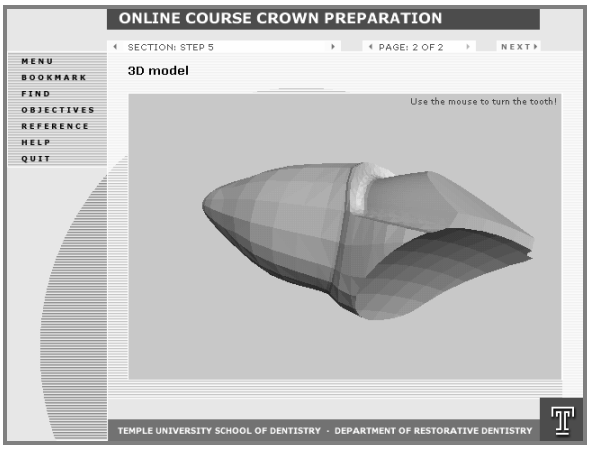

Figure 3: QuickDraw 3D Viewer: 3D tooth model.

Another key requirement was the ability to compare models of procedural steps with the actual technique of producing that step. Small video clips for each step of the crown preparation can be displayed on demand (see Figure 4).

Figure 4: Video clips for each step of the preparation

In order to access the different interactive features of the course, several plug-ins have to be installed on the client's computer to enhance the Web browser's capabilities. Authorware Full Web Player is a precondition to access the course itself, QuickDraw 3D Viewer is needed to interact with the 3D models (Fig. 3), and the Windows Media Player is necessary to display the video clips (Fig. 4).

CONCLUSIONS

We were able to produce an affordable and highly customized 3D Web-based crown preparation course by exploiting off-the-shelf technologies combined with limited programming effort. Thus, it was possible to use existing technologies to build a proprietary product.

However, we experienced technical difficulties which were mainly caused by immature products and version incompatibilities. These technical problems and the need for a well established support and training infrastructure limit the usage of such technologies to organizations which can meet these preconditions.

In addition, a remote usage is limited to users who are able to install several plug-ins to enhance their browsers—a procedure which requires a high level of computer literacy.

The effort to overcome these technical challenges can only fully pay off if we develop further courses with the same tools or, if we share this knowledge with other institutions which plan to develop similar simulation courses. This reuse would reduce the overall production costs per course.

In addition, some of the resources which were spent could be recovered by offering this or similar courses as dental continuing education courses. The initial market analysis for dental online CE courses supports such a move because of the lack of high-quality multimedia offerings.

ACKNOWLEDGEMENT

The authors want to express their thanks for various technical support they received during the development process, especially from Marc Getty (server and network administrator) and Ray Shepherd (camera for all video clips) (both Department of Dental Informatics, TUSoD).

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