University of Toronto’s Dental School Shows “New Teeth”: Moving Towards Online Instruction

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Abstract: This article presents the approach the Faculty of Dentistry at the University of Toronto employed to modernize its methods of instruction by using online technologies. A small team of faculty, students, and content developers was assembled to work with individual faculty members to brainstorm and research ideas for innovative teaching practices in dental studies. The team was not content to simply post digital versions of the ubiquitous PowerPoint lectures in Blackboard, selected in 2006 by the University of Toronto as its sole platform for online course delivery, but rather set out to introduce interactivity with the course material. Consequently, a series of interactive applications was created, such as the virtual microscope in Oral Pathology, the 3D cavity preparations in Restorative Dentistry, and the Master Media Repository. During the summer of 2006, the Faculty of Dentistry made progress toward becoming one of the university’s front-runners in online course innovation. The result of this collaboration between faculty members and the team was ten courses with interactive online presence, representing approximately 20 percent of the undergraduate curriculum. Since the summer of 2006, the Faculty of Dentistry has continued to pursue its goal of providing meaningful online instruction in all of its courses.

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It is, by now, an incontestable fact that web-enhanced education has steadily increased its presence in dental education over the past decade. Similar to many other domains of scientific and academic inquiry, the dental curriculum has undoubtedly benefited from the advent of new media to augment teaching and learning. This has been a progressive trend that began with the early days of email use for basic communication, both within dental education and in dental practice. It then continued with the Internet-based educational applications of more recent times. Numerous studies, such as those conducted by Fleming et al., Komolpis and Johnson, Schleyer et al., Schleyer et al., and Spallek et al. attest to the applicability and practicality of new learning technologies in the dental curriculum.

Dental schools across North America and, indeed, all over the world have moved at varying speeds towards integrating web-based applications in their curricula, in an effort to take advantage of the opportunities afforded by new or emerging technologies and their potential to effect positive change in dental instruction. One study, based on responses from sixty-four North American dental schools, stated in its Progress Report Card that instructional technology had already been implemented by “virtually all dental schools.”

Despite this trend of utilizing information technologies to help students achieve learning objectives in the dental curriculum, there are, however, indications of gaps in the overall application of learning technologies in dental curricula. Welk et al., for instance, claim that “computer-assisted learning (CAL) and computer-assisted simulation (CAS) systems still appear to be underutilized in dental education.” Certainly, in a sector such as e-learning (a very malleable and, at times, confusing term; for the purposes of this article, we broadly define e-learning as a notion that encompasses a varied array of methods for the delivery of instructional content via electronic means), the sheer volume and number of valid avenues to incorporate computer technologies...
in education will give rise to success in one area and failure in other areas, along a very wide range of strategies to adopt such technologies.

At the University of Toronto’s Faculty of Dentistry, the first indications of a faculty-driven interest in a web-enhanced curriculum were stipulated in the faculty’s academic plan for the period 2004–10. In the plan, titled “Best Learning Dental Institute,” two online learning modules were mentioned as potential models of web-enhanced instruction. One learning module, named “The Study Web,” was designed by a group of instructors in the Periodontology Department. The other module, named “Anatomia,” was created at the Faculty of Medicine and was considered useful in the dental curriculum. At this time, however, no data are available on the two modules’ frequency and effectiveness of use in the instructional process at the Faculty of Dentistry. The academic plan also mentioned the development of a virtual microscopy application for the discipline of Histology and the faculty-wide adoption of a package of digital textbooks called VitalSource. The academic plan left the development and implementation of future web-enhanced materials to a proposed “small working group focusing on the role of information technology at the Faculty of Dentistry.”

However, because of the absence of a robust web-based delivery platform for educational content, these proposals were not pursued proactively until the faculty joined the parent university in the official adoption of the Blackboard Learning Management System. The purpose of this article is to present the approach the Faculty of Dentistry took to make efficient use of the newly implemented system to enhance teaching and learning in its dental curriculum.

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First Steps Towards Digitization

Compared to other academic units of the University of Toronto, the Faculty of Dentistry had previously made virtually no use of the content management systems employed elsewhere on campus. Two factors may explain the sense of detachment that many faculty members at the Faculty of Dentistry experience in relation to central campus initiatives, including educational technology programs. Professional isolation from other academic programs is characteristic of the discipline of dentistry, as documented by Litchfield, Moltzer et al., and Pringle. At the University of Toronto, this pattern of isolation from other academic units has partly translated into the dental school faculty members’ tendency to perform educational tasks in seclusion. The separate physical location of the faculty in relation to the rest of the university’s campus is the second factor that compounds the faculty members’ feeling of detachment from the parent university.

Until the summer of 2006, only a handful of Faculty members made their course materials (lecture notes, journal articles, etc.) available on the limited space provided by the school’s library website. This pattern of adoption of technologies, however, is not peculiar to the Faculty of Dentistry. Evidence in the literature suggests that smaller organizations act less swiftly in the adoption of cutting-edge technologies than larger organizations. With an enrollment of approximately 450 students (undergraduate and graduate) and about eighty faculty members, the Faculty of Dentistry is a relatively small academic unit in comparison with other schools on campus, such as the Faculty of Arts and Science (22,000 students, 159 faculty), the Ontario Institute for Studies in Education (9,600 students, 149 faculty), the Faculty of Medicine (4,662 students, 1,964 faculty), and the School of Management (more than 2,300 students). While these departments had been more proactive in the use of educational technology, the Faculty of Dentistry had been relatively uninvolved in the adoption of digital technologies for teaching and learning. Moreover, there were other barriers to innovation diffusion at the Faculty of Dentistry, including a limited knowledge and experience base among the faculty regarding digital technologies, the perceived complexity of adopting technologies, and concerns about the compatibility of new technologies with existing values or practices. These factors may have contributed to the late start in the deployment of digital learning technologies.

Against this background, in January 2006, the parent institution, the University of Toronto, rolled out its plan to implement, by the beginning of the 2006–07 academic year, a single university-wide Learning Management System (LMS). An LMS provides educational establishments with the possibility of delivering course materials online to a restricted user base, which is commonly comprised of faculty, students, and staff members of an institution. It allows faculty members to upload course materials for student use and to track student performance in
individual courses. At the same time, students can access course materials, communicate with faculty members, and check their grades by signing into the LMS.

The purpose of the move to one LMS at the University of Toronto was to streamline the way in which the various academic departments were making use of the myriad opportunities available via the web to deliver course materials. In the absence of a centrally supported LMS, some academic divisions at the university, including the largest one, the Faculty of Arts and Science, were using CCNet as their LMS. A limited number of academic departments, including one of the university’s suburban campuses, were using WebCT. The proprietary CCNet was a “no frills” repository of digital documents and offered limited functionality to its users. It allowed them only to upload and access course materials and had none of the communication tools (discussion boards, email, chat, etc.) included in WebCT. Given the shortcomings of CCNet and the acquisition of WebCT by Blackboard at the beginning of 2006, the University of Toronto decided that the selection of Blackboard as the LMS of choice made practical and logistical sense. One other factor that helped expedite the decision was the fact that the university’s WebCT license, for those departments that were using it, was set to expire by the end of 2006.

At the initiative and with the strong support of its upper-level administration, the Faculty of Dentistry joined this undertaking with the intent of radically modifying the state of affairs in technology use in dental studies. In order to jumpstart the process of “digitization” of teaching practices with the help of the LMS, the Faculty of Dentistry initiated its own pilot project in the summer of 2006. It was an experiment with the goal of creating ten dental courses that were fully integrated into the LMS environment. Full integration here entails a complete transition to the electronic medium of course delivery—that is, replacing hard copy materials (e.g., lecture handouts) with digital course materials, providing unrestricted online access to audiovisual instructional components instead of one-time screenings during the lectures, using online communication tools to address student questions and needs, posting grades online for easy student access, etc. The aim of the project was to establish best practices in the meaningful and practical application of the newly adopted technologies, which could be used as models for the further integration of technologies in the rest of the dental curriculum.

The pilot project was funded from the Faculty of Dentistry’s Enrichment Endowment Fund. An application for funding from this source, under the title of “Supporting E-Learning Technologies at the Faculty of Dentistry,” was submitted jointly by the managers of the Computer Services and Media Services departments to the dean. Upon the dean’s approval, the pilot project received the funding necessary for hiring the staff responsible for the development of new digital learning tools.

Consequently, the Faculty of Dentistry assembled a small team of academic content developers, which included an academic technology specialist (ATS) as the team leader and project manager, two dental students, and two technology consultants. This team worked with the course coordinators or instructors of each of the courses selected for participation in the project. Through this project, it was hoped that the interaction among faculty members, students, and technology specialists would lead to new learning tools that would enhance the richness and effectiveness of the dental curriculum. Furthermore, the project was seen by its originators as a conduit for fostering more collaboration across disciplines and areas of specialization within the field of dentistry. The project initiators also considered that a collaborative environment could pave the way for the horizontal and vertical integration of the different curriculum components, across both years and subject matters. With this organizational and conceptual framework in mind, the pilot project members set out to work. The following section details the procedure followed to select the faculty members to participate in the summer project.

Selection of Participants

Initially, a total of ten slots were made available for the pilot project, meaning ten courses from the D.D.S. undergraduate curriculum, with no specific preference for any one of the subject areas covered in dentistry (Biomaterials, Oral Radiology, Oral Surgery, etc.). Subsequently, a call for participation aimed specifically at faculty members was distributed online during the month of April 2006 via a web-based application form. By the end of the call for participation, twenty-three individual responses were received from faculty members in different disciplines.

After the call for participation was closed, the ATS interviewed each of the twenty-three individual
establish a collegial rapport with the faculty members; assess the level of interest and general knowledge each faculty member had in incorporating technology into his or her course; determine whether the faculty members had interesting and novel ideas of their own as to how technology could be used to suit their course plans; evaluate the clarity and direction of the course material and its suitability for the generation of innovative technology-enhanced practices; establish a collegial rapport with the faculty members for collaboration in the project; and ensure that the potential participants would be available throughout the duration of the pilot project, since weekly meetings between the content development team and the faculty members were crucial for the success of the project.

Based on these guidelines, the ATS nominated ten faculty members for participation in the pilot project. Following consultations with the managers of the Computer Services and Media Services departments, the list of nominations was submitted to and subsequently approved by the dean. The ten faculty members selected were notified via email of their acceptance in the pilot project, while the other thirteen faculty members who had responded to the call for participation were invited to collaborate in future courseware development. Several of the thirteen faculty members replied and expressed their interest in participating in similar future projects.

The ten faculty members selected were the ones who displayed a high level of enthusiasm and openness for the use of technology in their courses to improve both teaching and learning. By and large, these faculty members showed that they had already assembled or were in the process of organizing their course material for the coming academic year. While this certainly indicated that they were efficient instructors with clear goals for their courses, the ATS wanted to make sure that they were not confining themselves to the old materials that they had used over the years in their courses. This would have meant a reduction of the project’s scope to the mere conversion of course materials from hard-copy to digital format. The way the project had been envisioned, there had to be a good measure of exploration, discovery, and reinvention of the teaching materials to be used in order for new practices to arise from this undertaking. The ten faculty members selected were the best qualified individuals to understand and apply this philosophy.

In the end, two first-year courses (in Biornaterials and Restorative Dentistry), one second-year course (in Prosthodontics), and seven third-year courses (in Community Dentistry, Endodontics, Oral Medicine and Pathology, Oral Surgery, Orthodontics, Pediatrics, and Periodontics) were included in the project. The ten instructors teaching these courses and the content development team were now ready to begin their work on the project.

The Project Unfolds

Any project needs a comprehensive and well-considered plan in order to succeed. Taking into account the time constraints placed on the pilot project (ten weeks over the summer), the amount of course material that had to be generated, and the limited financial and human resources available, it was imperative that this project had a clear plan with well-defined stages of development. The ATS devised a week-by-week plan with milestones to be achieved by the end of each week. The following is both a description of the plan’s schedule and a retrospective report of the workflow that ensued from the deployment of the plan.

The first week was primarily intended as a period of familiarization of the team members with the objectives of the pilot project and the division of tasks among the team members, as well as a time to build a collegial relationship among them. Thus, the ATS, in his role as team leader and person responsible for the overall management of the pilot project, assigned each of the two students a total of five courses on which work had to be done. They were responsible for the general layout of the courses in the LMS. Their expertise as consumers of the didactic material that was to be created was very valuable in the process of content development. More importantly, the students were responsible for articulating their opinions to each course instructor so that the latter would have a better idea of what the expectations of students were regarding the breadth, depth, and complexity of the learning materials to be produced. The two technol-
ogy consultants were entrusted with the technical aspects of the development process. This meant that they would perform the video editing, the graphic design, and the programming of the user interface for the digital tools described in the next section of this article.

During the first two weeks of the pilot project, individual meetings with each of the instructors directing the ten courses focused on the overall direction that each course should follow. These were, by and large, brainstorming sessions that entailed a review of the then current teaching practices in the respective courses and a proposed course of action for the creation of either new material or a morphing of existing material into new digital components. Everyone involved offered ideas or solutions on how to best incorporate technologies, what course materials should be developed, and what existing material could be utilized in the context of the new technologies. These first meetings were crucial for the crystallization of a coherent production process as well as for the emergence of a collaborative environment, based on collegiality and mutual trust among all parties involved.

With this groundwork laid, during the third week of the pilot project, the team proceeded with gathering the existing materials to be included in each course hosted in the LMS. The conversion of these materials to digital format and their uploading into the LMS were rather ordinary but necessary tasks, and, as such, they did not constitute the innovative part of the project. This process, however, allowed instructors to learn how to, for instance, optimize the images they would include in their presentations (e.g., PowerPoint lecture slides), so that they could keep file sizes to a minimum for faster online viewing. More importantly, in the long term, it also provided them with an opportunity to learn how to use the LMS and, by extension, manage their own courses. By the end of the fourth week, the process of optimization of existing media was well under way. At the same time, the development of new media files was initiated.

The process of optimization of existing media was completed at the end of the fifth week, and their inclusion in the LMS was performed during the sixth week. The more substantive achievements of the group were to come after the midpoint of the project, beginning with the sixth week. Several factors combined to give rise to a number of original digital applications geared for the dental curriculum. It was the continued exchange of ideas, the reshaping of the course components that were being manipulated, the pedagogical perspective of the instructors, and the specific input of the two dental students in the group that led to the creation of these new instructional tools. Between the sixth and the ninth weeks, these new applications constituted the bulk of the team’s workload.

Although these tools could work as stand-alone objects for learning, their use in their respective courses was considered not only obligatory by the group members, but also pedagogically sound. The overarching objective was to create fully integrated educational models that could be employed not only within one course but, indeed, between courses and study years. It was, therefore, decided that the new applications would be integrated into the LMS within the courses to which each one pertained. At the same time, the group ensured that instructors in other dental disciplines who would potentially show interest in using the applications for their own courses could easily access them within the LMS. Concurrently, the development and optimization of the new media components (new video procedures, lecture slides, graphics, etc.) were completed during this same period of time. As they were produced, the media files were incorporated into their corresponding courses.

To accommodate the potential demand for course cross-linking, all course materials developed during the project were placed in the institutional content area of the LMS to which all university users with appropriate login credentials could have access. Figure 1 shows the directory structure set up for the dentistry courses in the LMS. This setup allows instructors to link from their courses to the materials they deem relevant in other dental courses.

As it turned out, this structure was an appropriate solution for dental courses, considering the nature of the course content and the need for a space to share that content among disciplines and subject areas. Once the reorganization and digitization of pre-existing content and the development of new content were concluded, the entire body of this material was stored in the hosting space available in Blackboard. The last week of the project was reserved for the testing and quality assurance of all the applications produced. Matters such as pedagogical relevance, design aesthetics, loading times for online viewing of media components, storage space adjustments, etc. were considered and checked.

Following the conclusion of the pilot project, the main objectives were achieved: namely, ten courses were fully integrated into the new LMS and
used innovative digital tools for instruction. The next section provides a brief description and examples of some of these tools.

**Palpable Results**

Three applications developed during the project stand out as models of digital learning objectives at the Faculty of Dentistry: the Oral Pathology Virtual Microscope, the Virtual Cavity Preparations, and the Master Media Repository.

**Oral Pathology Virtual Microscope**

In an effort to eliminate the dependency on the aging microscopes at the Faculty of Dentistry, the pilot project group developed the Oral Pathology Virtual Microscope for students taking courses in oral pathology and medicine. This new application allows students to access a series of anatomical slides online via the course’s Blackboard interface, effectively replacing the use of conventional microscopes in the course. High resolution images of anatomical preparations were processed with Zoomify Enterprise. The images are divided into progressive layers of magnification, up to twenty times the original size. Each layer is represented by a tile group that contains the images for a certain level of magnification. The final product, rendered in Adobe Flash Player, allows the user to pan, zoom in and out, rotate, and reset the image, making it an ideal object for online viewing. A snapshot of a virtual slide is presented in Figure 2.

The example in Figure 2 shows the virtual slide incorporated in a webpage opening in a new window from a link placed in the course’s main page in Blackboard. The slide in this example shows the default mode in which the slide opens on the screen, that is, with “Annotations ON.” This means that the students have the option of navigating (either through the drop-down menu in the top right-hand corner of the slide or by panning and zooming) to a certain section of the slide indicated with a label, allowing students to learn specific components of the microscopic preparation. A second mode of displaying the slide is the “Annotations OFF” option, which simply means that the annotations are removed and the student can either test his or her newfound knowledge of the subject matter learned in the first mode or engage in discovery learning. Finally, the students can choose the “Split Screen View” mode, which displays mode 1 and 2 side by side, for comparison viewing.

The page includes additional context notes for the slide content on the right-hand side of the slide. Where relevant, radiographic images are provided to
pinpoint the anatomical location of the microscopic slide preparation. There are several advantages to virtual slides over regular slides:

- The virtual slides are available around the clock from anywhere via the web, thus removing the need for the limited access to conventional microscopes.
- The order of magnification and the resolution of the virtual slides are significantly higher than those of the conventional microscopes in current use.
- There is no risk of breakage and loss of microscopic preparations involved in the development of the virtual slides, as is the case with traditional glass slides.
- The students have multiple options of learning, at their discretion, the pertinent concepts in oral pathology, by using the annotated slides, by exploring the non-annotated slides on their own, or by combining the two options.

**Virtual Cavity Preparations**

A series of seven learning objects, called Virtual Cavity Preparations, was developed for a course in Restorative Dentistry. The core of these objects consists of the three-dimensional images of tooth preparations rendered in Quicktime, each of which allows the user to rotate the tooth 360° on its horizontal plane and view all of its facets. Users can also zoom the tooth in and out for detail viewing. Figure 3 shows one of the learning objects in its online environment.

In each case, between thirty-five and fifty high-resolution images were taken with a digital camera around the vertical axis of a tooth model. The resulting images were collated and processed in the VR Works program, which rendered the interactive Quicktime movie presented above. Similar to the virtual slides, each movie was made part of an integrated model for learning, which included, apart from the movie, several relevant, high-resolution still images of key parts of each tooth. Where important components of the preparations had to be highlighted, the still images included annotations to help the students contextualize the visual components of the material presented. The Virtual Cavity Preparations can potentially improve the teaching and learning of restorative dentistry by

- providing the students with immediate and constant access to cavity preparations online, thus increasing the amount of time they can spend studying them;
- eliminating the need for the instructor(s) to create and annotate physical versions of tooth models, which are normally discarded after use (new gyp-
Master Media Repository

Providing students with convenient and easy access to videos of dental procedures and images of dental instruments had been a chronic problem at the Faculty of Dentistry. The Master Media Repository was created with the intention of alleviating this problem. An extensive collection of older and newly created images and videos was placed in the repository. The repository was then linked to each course’s page so that all dental students could access the media files, regardless of the students’ year of study or the discipline to which the media files pertained.

The master repository, technically speaking, is a collection of repositories for each dental discipline. A simple two-framed webpage contains a top menu in the upper frame, with links to each discipline’s repository that is displayed in the lower frame. Each repository, programmed and designed in Acrobat Flash, contains an XML file that specifies the general attributes of the navigational tools used to display the media components as well as the order in which the media files are arranged for each particular discipline. The video clips and the high-resolution images are stored in a media folder for the respective discipline in the Blackboard directory structure shown in Figure 1. Figure 4 presents a screen from a video clip playing in the master repository.

The video clips were converted to Flash movies from original footage of dental procedures either filmed on videotape or from other digital formats such as MPEG, MOV, AVI, etc. Flix Pro 8 was used for the task of converting the video clips, a process that compressed the size of the movie files. In many cases, where digital-to-digital conversion occurred, the output file was reduced by as much as ten times from its original format. This reduction in file size ensured that the storage space available in Blackboard was judiciously used and, more importantly, that the clips would take as little network bandwidth as possible while being accessed by users online. Both the images included in the discipline repositories and the video clips can be displayed in groups of fifteen per page or individually. This last option allows users to enlarge or shrink the images as needed.

When using the master repository, the students can move from one discipline to another, by selecting the appropriate discipline from the top menu. Once
they access the repository for a certain discipline, they can browse through the available media by selecting the secondary menu (named main menu in the actual discipline repository) underneath the top menu. In most cases, the disciplines have a series of instrument kits and a series of video clips, each distinctly labeled in the menu and submenu categories. The Master Media Repository enhances the dental students’ learning needs in several important ways:

- It grants the students access to review videos of procedures at any given time, whereas previously they were limited to viewing the films once during class.
- It eliminates the need to sign out instrument kits for a limited time. Now, instrument kits can be viewed from any computer connected to the Internet.
- It has the potential to display an unlimited number of media files that the students need to view and/or review for lectures, labs, exams, etc.
- It allows students to review past material as well as view material they would encounter in future courses.
- Due to the visual nature of dental studies, which rely heavily on mixed media, it plays an important role in the model of horizontal and vertical integration mentioned previously in this article.

Conclusion

As a novel undertaking at the Faculty of Dentistry, the pilot project acted as the medium for a new type of collaboration among the faculty members. Traditionally, instructors at the Faculty of Dentistry preferred to keep their pedagogical methods largely intact and to safeguard against any intrusion from their peers related to their teaching materials. Modern technologies have been the catalyst for a change in perception, albeit still in its infancy at the Faculty of Dentistry, of the kind of collaboration necessary to plan and implement a more fully integrated curriculum that helps students understand how various subjects and learning experiences relate to one another.

In the end, the pilot project achieved its quantitative target of ten courses that were available to students by means of the new Blackboard LMS. These ten courses represent roughly 20 percent of the current dental curriculum. The project team also developed innovative teaching applications that were usable across the curriculum, which met the project’s qualitative requirements. The process of “technologization” induced by the pilot project has continued since the summer of 2006, but is far from over. At the time of this article’s writing, thirty-four
of the fifty-five undergraduate dental courses (61 percent) now use some type of digital courseware. While instructors in some courses have only basic digital materials hosted in the LMS (lecture slides, course outlines, etc.), their move towards digitization would have plausibly occurred at a slower pace in the absence of the impetus given to this process by the pilot project.

Currently, there are no conclusive data regarding the effectiveness in teaching and learning of the digital applications produced during the pilot project. There is, however, some indication of the impact that the pilot project has had upon the use of new learning technologies at the Faculty of Dentistry. In February 2007, the Faculty of Dentistry conducted a survey designed to assess dental students’ perspectives covering a broad range of technical, clinical, and didactic issues related to computer use in dental education. In 119 of the total 292 voluntary write-in essay responses to all topics covered in the survey, the students made statements indicating that they perceived the new digital applications to be valuable and/or expressed an interest in using more interactive learning tools in the future, such as 3D graphics, audio and video lectures, simulations, etc.30 A concurrent survey distributed to faculty members at the Faculty of Dentistry revealed that twenty-eight of the thirty respondents (93 percent) were using multiple technologies in their teaching practices. In addition, twenty-five of the thirty faculty respondents (83 percent) were interested in learning more about multiple technologies to enhance teaching.31

Building on the achievements of the 2006 pilot project, the development of digital learning tools continued in the summer of 2007 with a new courseware creation project, and several new applications have resulted from this project. In the final analysis, over the course of the last year and a half, the Faculty of Dentistry has made progress in the development and utilization of digital technologies in teaching and learning. This activity may also help bring the school a step closer to fulfilling its self-imposed goal of becoming the “best learning dental institute in North America”16 in the years ahead.

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