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21st Century Cognitive Apprenticeship: An Interactive Digital Textbook to Teach Dentistry Students from Classroom to Clinic

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Abstract

Dental education closely emulates that of an apprentice's interactions with a skilled master. Collins, Brown and Newman's (1989) cognitive apprenticeship educational theory provides a framework for understanding this unique interaction, which includes modeling, coaching, scaffolding, articulation, reflection and exploration. However, what happens when the skilled master is unavailable the night before the final examination, busy helping another student in clinic or, even worse, retiring? The iBook, an interactive digital textbook, combines text, photos, videos, 3-D models and interactive animations, and may offer the potential to not only capture but also replicate some of the roles of the skilled master. We will demonstrate how the development and implementation of a complete denture prosthodontics iBook offers a 21st century approach to cognitive apprenticeship. The journey from classroom to clinic can encourage student articulation, reflection and exploration when courses are designed to integrate a tool that provides continuous access to modeling, coaching and scaffolding.

Project Description

Context and Background

Pre-clinical dental students participate in the DDS 529 Complete Denture Prosthodontics course in the Fall term of their second year which is comprised of a lecture and clinically-based laboratory. In the DDS 545 Removable Prosthodontics course, which runs from the Fall through Summer terms of their third year, students treat clinical patients. In the DDS 565 Removable Prosthodontics course, which is their fourth and final clinical year, students are required, upon successful completion of at least one complete denture clinical case, to take a clinical competency examination. This requires them to work independently to make a complete upper denture that is evaluated at checkpoints with an evaluation rubric. The DDS 529 course is structured to tightly integrate with the DDS 545 and 565 courses such that the chief instructors in the pre-clinical course also teach in the clinical courses. This allows for a consistent treatment philosophy and methodology to be maintained throughout preclinical and clinical. Historically, however, students have struggled with retaining their theoretical knowledge between pre-clinical (in year two) and clinical (in years three and four) courses and have a tendency to rely on clinical instructors to provide live demonstrations as a means of learning prior to attempting to do the treatment on their own. There is a need for increased modeling of the denture fabrication and treatment process and a scaffolding mechanism to bridge this inherent time lapse in the curriculum sequence.

A Cognitive Apprenticeship Educational Framework for iBook Development

Putting the learner in control of their knowledge construction falls within the cognitive domain and, more specifically, constructivist learning theory. A challenge for constructivist learning is the establishment of new methods of instructional design that gives students a more active role to learn more effectively (Schroeder & Spannagel, 2006). A successful method of implementing constructivist theory in the teaching of the medical profession has been the cognitive apprenticeship model (Durak, Çertuğ, Çalişkan, & Van Dalen, 2006; Stalmeijer, Dolmans, Wolfhagen, & Scherpbier, 2009). Collins, Brown, and Newman's (1989) cognitive apprenticeship model (CAM) has six components: modeling, coaching, scaffolding, articulation, reflection and exploration. The iBook, as a compound learning object, may be an exemplar method for modeling and scaffolding complete denture prosthodontics to preclinical and clinical dentistry students by which coaching, articulation, reflection and exploration can be facilitated.

Watson (2010) argued that too much emphasis has been placed on visual attractiveness and technological impact when it comes to learning object design, rather than focusing on pedagogy and how the learning object supports scaffolding for the student. Güler and Altun (2010) echoed similar sentiment in stating that software applications, on their own, do not produce pedagogically sound learning objects and instead recommend teachers as necessary learning object content developers. After all, who better understands the pedagogy than the trained educator? It therefore becomes important to understand how instructional designers conceptualize learning objects to provide teachers better insight into how best to develop them. Francis and Murphy (2008) did exactly this and presented their findings as learning objects having the following attributes: digital, interactive, pedagogically purposeful, pedagogically worthwhile, pedagogically assessable, usable, reusable, peer reviewable and granular.

With these concepts in mind, one of the applicants for this project created a complete denture prosthodontics iBook as his capping project for the Master of Education in Health Sciences Education. The iBook is a digital file that runs in the iBooks software on an iPad and therefore meets the *digital* requirement. *Interactivity* is seen as a spectrum from low, such as being able to highlight or make notes on the text, to high, such as developing critical thinking. The iBook allows for interaction with text, including highlighting text and making notes as well as three-dimensional models (see Figure A1) and interactive figures whereby directly touching the screen changes the view or information provided by the figure (see Figure A2). Being *pedagogically purposeful* is demonstrated by starting each chapter with learning objectives for each of the DDS 529, 545 and 565 courses and ensuring that the chapter content covers them.

Pedagogically worthwhileness is shown by the incorporation of demonstration videos that help explain difficult concepts that students often struggle with and which cannot be easily explained by mere text and/or photos. With appropriate design, the videos show a skilled master carrying out procedures and serve as exemplars of modeling within the CAM that can be judiciously included in the iBook. Interactive quizzes at the end of the chapters allow for student feedback and assessment on their understanding of what is *pedagogically purposeful*. *Usability* pertains to being "easy to use". Students who are unfamiliar with how to interact with the iBook would have access to a website that demonstrates the iBook's features and use. Given the touchscreen capability of the iPad, the iBook is afforded a tactile experience much closer to that of a physical book than a computer screen could previously provide.

The importance of *reusability* also becomes an important consideration due to the significant amount of time required to create learning objects. Consideration towards the threshold between developing a simple or compound learning object will ultimately determine how reusable it will be across content and context. Simpler learning objects such as short videos allows for them to be incorporated into the more compound learning object of the iBook. However, as complex as the iBook is, it has still been designed to be reusable across contexts in three separate courses. *Peer review* has also been incorporated into the iBook via feedback from colleagues and future academic dissemination (conferences and articles). Student feedback has also been a form of peer review in contributing changes to the content or how a concept is explained in the text.

Learning objects can be simple, offering 'bite-sized' chunks to learn, or they may linearly integrate together to become more compound as the learning objective requires. This range in *granularity*, the final attribute, allows the content to be integrated across multiple courses or even for stand-alone use (Watson, 2010). The concept of simple and compound learning objects does not only apply to the content matter, however, but also the format of the content. While the iBook creation software is, for the most part, user friendly, the development of the three-dimensional models as well as complex interactive images is a challenging obstacle, best left to the industrial designers and visual learning designers. While the trained educator may understand the pedagogy and can use it to create a compound learning object such as the iBook, learning object design and visual learning design also needs to be implemented to illustrate critical concepts and ensure that the student will want to read a textbook that they will use across three courses.

Proposed TLEF Project

There are three main objectives for this TLEF project:

1) Collaborate with Design Studies at the University of Alberta to create and add three-dimensional models and complex interactive images and implement a visual learning design to the iBook.
2) Provide iPads (as the interactive mechanism for the iBook) to a cohort of dental students to remove any 'digital divide' so that they all have access to modeling and scaffolding across the DDS 529, 545 and 565 courses and then assess their didactic, laboratory and clinical performance to determine whether learning, Level 2 of the Kirkpatrick Model of Program Evaluation, has improved compared to a cohort who did not have access to the iBook. Student focus groups and surveys will also be used to collect data during each course to provide feedback for improving the iBook (i.e. adding more interactive elements) and informing the development process.
3) Establish a practical framework for the development and implementation of an interactive digital textbook, such as the iBook, to disseminate to fellow faculty members to facilitate the establishment of a library of iBooks for dental students to use as part of the current curriculum renewal within the School of Dentistry and other appropriate areas at the University of Alberta.

Ethics approval would be required for this project. Ethics approval has previously been obtained for Level 1 of the Kirkpatrick Model of Program Evaluation, the dental students' reaction to the iBook in its draft version.

Innovation: A recent submission to the Bookstore Strategic Plan by the University of Alberta Students' Union made recommendations that students be given the option to

purchase an electronic version of course material, especially if cost is reduced, to continue support for custom courseware and to ensure course materials have lasting value. The creation of an iBook by a course instructor is an exemplar of the recommendations. The creation of 3-D models and complex interactive images will allow students to better understand difficult concepts that could not otherwise be explained through typical medium such as text, still images and video. As recently developed software, the iBook currently shows paucity in the literature. Developing a practical framework to its creation and application, particularly as a cost effective easy to use method for university faculty to create custom courseware, would be leading edge.

Collaboration: The creation of 3-D models and complex interactive images as well as implementation of visual learning design will be done in collaboration with Design Studies at the University of Alberta and will include graduate students facilitating research and learning opportunities. A draft version of the iBook was previously provided to undergraduate dentistry students to provide anonymous feedback, which will be used to direct the initial updates to content and design. Also, a questionnaire assessing Level 1, reaction, of the Kirkpatrick Model of Program Evaluation was also provided to students to understand their use of the iBook and how to improve it according to their needs.

Evaluation: The 2019 Dentistry Class cohort will be provided with an iPad and copy of the complete denture prosthodontics iBook for use in DDS 529, 545 and 565 across three years of the program. Their grades in all three courses, including the final competency examination in the forth year, will be compared to a previous cohort who did not have access to the iBook. These grades will be used as a measure of learning, or Level 2 of the Kirkpatrick Model of Program Evaluation. The hypothesis is that having the modeling and scaffolding provided by the iBook will result in higher grades than the previous cohort. The use of questionnaires and focus groups to evaluate students' perception of improved learning with the iBook will also be administered to the students after each course. Students will be able to leave anonymous online feedback for improvements to the content of the iBook throughout the project and will direct further updates.

Sustainability/Impact on Students: Starting in 2019, the National Dental Examining Board will be administering the examination for licensure in Canada on an iPad. Given the high stakes of this examination, having previous familiarity with reading and interacting on an iPad will be of significant benefit to the students. Where the results of this project demonstrate an improvement in learning of the dental students with the iBook, the impetus among fellow faculty members to create an iBook for their subject will grow, with the goal to establish a library of iBooks within the School of Dentistry. With interactive digital textbooks being cheaper to develop and maintain than external course materials, the cost savings and time saving of a course text that is specific to what is being taught in lectures and clinics will be of significant benefit to the students. Within the School of Dentistry, other faculty have expressed interest in creating an iBook, which would provide further incentive for students to purchase their own iPad in the future. However, until it can be demonstrated to a cohort of students that having an iPad is beneficial to providing a mechanism for development of 3-D models and complex interactive images to best explain difficult concepts and that it may improve their learning outcomes, it may otherwise be difficult to get full student buy-in. Similarly, when faculty learn that a cohort of students all have iPads and therefore can access their iBook, it may incentivize faculty to continue with their development, especially if this project establishes a practical framework for them

to do so in a time-efficient and effective method. As mentioned earlier, a main barrier to development of an iBook is the creation of 3-D models and complex interactive images when required. Thus, the need for collaboration with Design Studies graduate students will likely be in perpetuity. Charging a nominal amount for copies of the iBook could offset the cost of further interactive elements added to this iBook. A cost model could be established by which other iBooks in the School of Dentistry and beyond might benefit from.

Dissemination: Presenting this project to fellow School of Dentistry faculty members as part of the School's faculty development "Teaching Excellence Program", early in the first year of this project could encourage other disciplines within dentistry to develop an iBook while a class cohort has iPads. A poster presentation will be submitted for the FoMD Celebration of Teaching and Learning event which would additionally spark interest in the Faculty at large. As an invitee to the American Dental Education Association's Annual Session and Exhibition to present on the dental students' reaction to the draft version of the iBook in March 2016, one of the applicants on this project would also be a candidate for an invited workshop on iBook development in the future. In addition to preparing a manuscript for submission to the Journal of Dental Education, the primary resource for current research in dental education, on the evaluation of student learning using Level 2 of the Kirkpatrick Model of Program Evaluation, a manuscript on the process of creating an iBook would also be written. Ultimately, this would be applicable not only to dental education but to any university-level course that is looking for an interactive way to engage students with custom courseware in digital format.

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Appendix

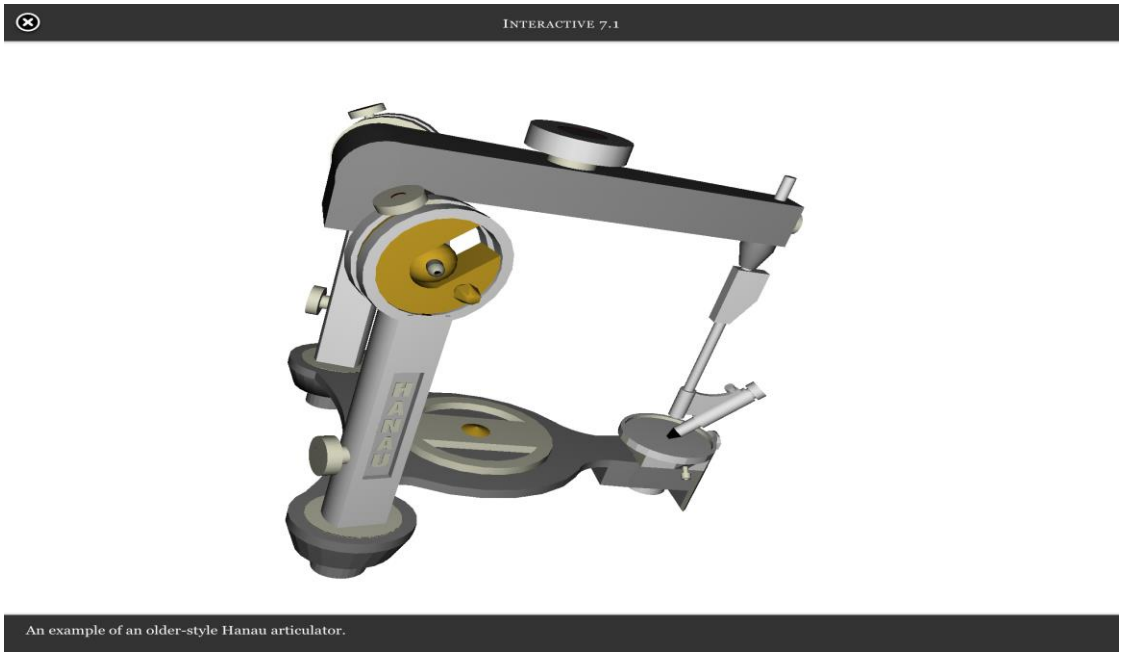

Figure A1. Three-dimensional models.

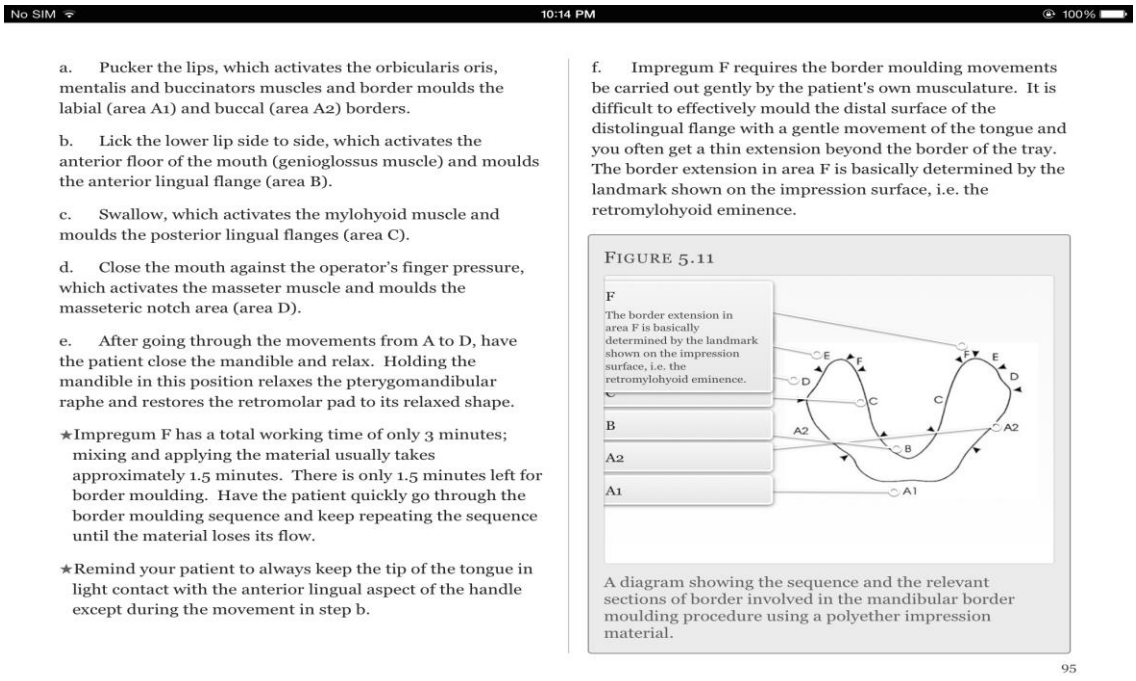

Figure A2. Interactive figures.