A Novel Interactive Online Module in a Traditional Curriculum through a Blended Learning Approach

Leslie Laing Gibbard and Florin Salajan
University of Toronto, Canada
leslie.lainggibbard@dentistry.utoronto.ca
florin.salajan@dentistry.utoronto.ca

Abstract: A unique approach was planned and implemented for undergraduate dental students that would reinforce the principles of removable partial denture (RPD) design. 162 students were grouped according to their year of dental studies (66 second-year students and 96 third-year students) within the Discipline of Prosthodontics at the Faculty of Dentistry, University of Toronto. Previous training for the students consisted of the traditional Socratic approach, including lectures, seminars, and laboratory pre-clinical hands-on exercises. During the testing session, all the students were given the case history of a particular patient. One half of each of the classes was instructed to design an RPD using the traditional, clinically-related approach, with a dental model that could be touched and seen, dental surveyors, and writing instruments. When finished, various treatment options were discussed. The other half of the classes was given the same instructions but saw the dental model only in animated form *via* a computer-based e-learning scenario. The RPD was virtually fabricated with student choices of drop-down design features made in a particular orderly sequence as the students worked step-by-step through the computer simulation. A pre-test questionnaire was given to all students concerning their design choices, the order in which they chose the denture components, and their learning experiences. All students were then asked to design an RPD for a different but similar case using dental models in the traditional clinical manner. Post-test questionnaires were given to assess the effectiveness of the method of their pre-test technique, in addition to their enjoyment of the approach. A cross-over situation followed one week later, whereby each group of students went through the alternate approach from the previous session. The results from the third-year student data and implications of this blended approach for teaching and learning RPD design are analyzed and discussed.

Keywords: e-learning, dental education, computer-aided learning, computer simulation, removable partial denture design

1. Introduction

As is often the case in undergraduate university settings, a course coordinator has the responsibility not only to design the overall outline of the course but also to solely present or invite other instructors to present various sub-topics pertaining to their area of expertise. Teaching within dental faculties has followed a similar venue and has traditionally taken the approach of the Socratic style, *i.e.,* that of lectures, seminars, and laboratory pre-clinical hands-on exercises. One topic in the area of prosthodontic education that has had a tradition of being difficult for students to master has been that of Removable Partial Denture (RPD) design. Although there are a number of computer software programs available that feature various aspects of RPD design (Beaumont, 1989; Beaumont and Bianco, 1989; Hammond *et al*., 1993; Wicks and Pennell, 1990; Lindquist *et al*., 1997; Lechner *et al.*, 1998; Lechner *et al*., 1999), interactive online modules have neither been designed not formally tested at the pre-doctoral level. With this in mind, a unique approach was planned and implemented for incorporation into the undergraduate dental curriculum to enhance students' mastery of RPD design. Assessment of the application was performed by summative means.

1.1 Prosthodontic training

During their traditional pre-clinical prosthodontic training, the students are introduced to the various terms used within the discipline of Prosthodontics, and are taught the fundamental concepts of RPD design including features of support, stability, and retention. Traditional (Kennedy-Applegate (Kennedy, 1923; Applegate, 1960)) and contemporary (Prosthodontic Diagnostic Index (McGarry *et al*., 2002)) classification systems of denture designs are presented as well as the types of clasps and materials used in the fabrication of the RPDs. Techniques on how to make accurate impressions of patients' oral structures including teeth, gums, and surrounding soft tissues are presented as well as how to pour up such impressions in various dental stone materials. Once the stone models or casts have been made, methods on how to survey the casts and how to design appropriate RPDs using various denture components are presented. During this process, the students learn the importance of the angulations of the models and the proposed paths of insertion of the prosthodontic appliances

Reference this paper as:
Gibbard, L, L, and Salajan, F. "A Novel Interactive Online Module in a Traditional Curriculum through a Blended Learning Approach" *Electronic Journal of e-Learning Volume 7 Issue 3 2009, (pp301 - 308), available online at www.ejel.org*

such that the final RPDs are not only easy for the patients to insert and remove, but are also sufficiently retentive during the chewing of sticky foods, without causing undue stress on either the remaining teeth or underlying soft tissues. Other considerations include the aesthetic aspects of denture design such as whether or not to incorporate visible retentive clasps, stress-relief components, technically-complex precision attachments, or functional features for enhanced speech articulation.

1.2 e-Learning module

For this computer-based e-learning scenario, a novel approach was planned and tested based on the traditional and logical planning steps of RPD design principles. A decision-tree logic involving pre-determined choices was employed in developing the module, so that the students would be guided through a series of choices leading, in the end, to a correct version of an RPD. Thirty possible valid prosthodontic designs were retained as acceptable outcomes of the steps followed in the simulated design in which the student engaged. The e-learning module was developed in-house at the Faculty of Dentistry, University of Toronto, with the contribution of:

- two dental students, who worked out the logic and sequence of the decisional steps to be included in the RPD design;
- a web programmer, who converted the decisional logic generated by the students into a functional algorithm in the module;
- a biomedical animator, who created the three-dimensional casts presented to the student at key points during the course of the design; and
- a web developer, who created the overall graphic design of the module as well as the navigational commands allowing the user to advance from step to step in the application.

The RPD e-learning module was built using *Adobe Flash CS3* and *ActionScript 2* for the design and programming of the dynamic and interactive elements involved in the decisional tree. *Autodesk Maya 8.5* was used for the generation of both the static and the animated three-dimensional images of the RPD casts. *Adobe Dreamweaver CS3* was used to assemble the web-based components of the e-learning module. Once the module was completed, it was hosted for web access on an internal server at the Faculty and subsequently made available to the students in the course via the *Blackboard* learning management system. The program was designed for use by dental students who were familiar with the terms and functional elements associated with RPD design. The module included a brief medical and dental history as introduction to the virtual patient as well as an animated, three-dimensional image of a cast of the patient's maxillary (upper) arch as illustrated in Figures 1 and 2 below.

Figure 1: The initial screen of the e-learning module, showing the patient's dental history

Figure 2: Screen of the e-learning module showing the patient's model of the maxillary arch

Based on the number and location of missing teeth, students were asked to categorize the patient's maxillary arch with respect to the Kennedy-Applegate Classification System (Kennedy, 1923; Applegate, 1960). The animated cast was portrayed from all appropriate angles and could be rotated 360º. In order to emphasize the concept of retention of an RPD, the cast was also displayed with various tilts. Five views were illustrated, as shown in Figure 3: no tilt (where the base of the cast was parallel to a tabletop), with an anterior up-tilt (with the front teeth raised higher than the back teeth), an anterior down-tilt (with the back teeth raised higher than the front teeth), or with the left or right side raised higher than the right or left side, respectively.

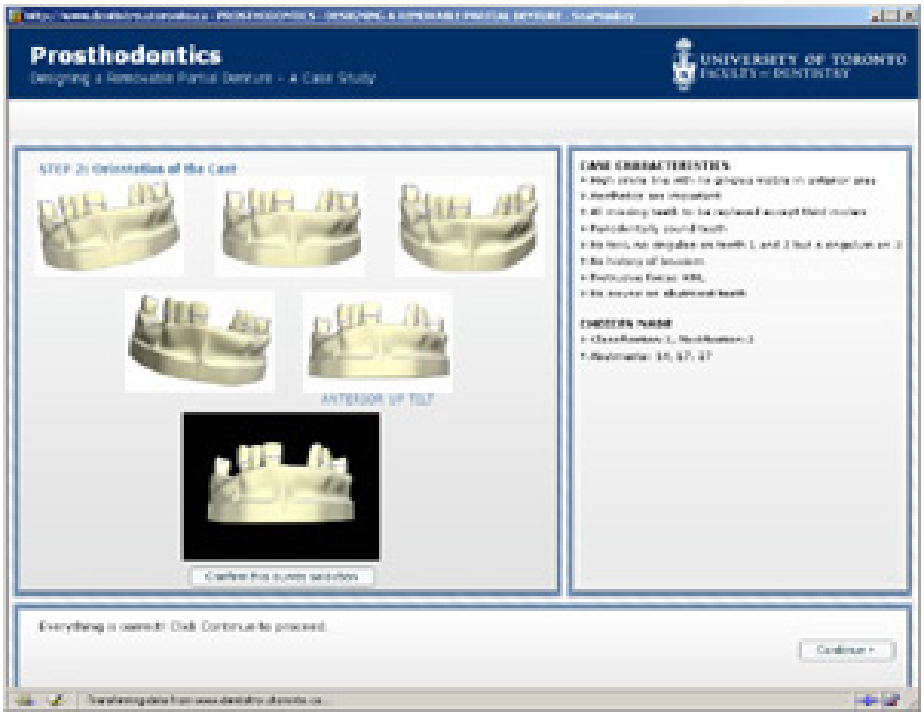

Figure 3: Application screen showing the tilt orientation of the RPD casts

Each student was required: to choose abutment teeth, *i.e.,* those requiring clasps; to design the clasps for those abutment teeth; and to select the materials used for clasp fabrication. If a clinically-unacceptable choice was made anywhere during the step-by-step design activity, the student was informed, was asked to reconsider his/her choice, and could not proceed further until a clinically-acceptable choice had been made. In essence, the student was guided through the scenario by visual cues alerting him/her to the appropriateness of selections made (correct or incorrect) from a series of drop-down menus containing a certain number of choices representing particular elements or components of the RPD. Consequently, the student was "forced" to complete the program successfully by designing one of the thirty possible scenarios contained in the module. Upon completion, the program provided a method of formative evaluation. In addition, at the end of the simulation, the cumulative, clinically-acceptable RPD design appeared in animation for the student's inspection (see Figure 4).

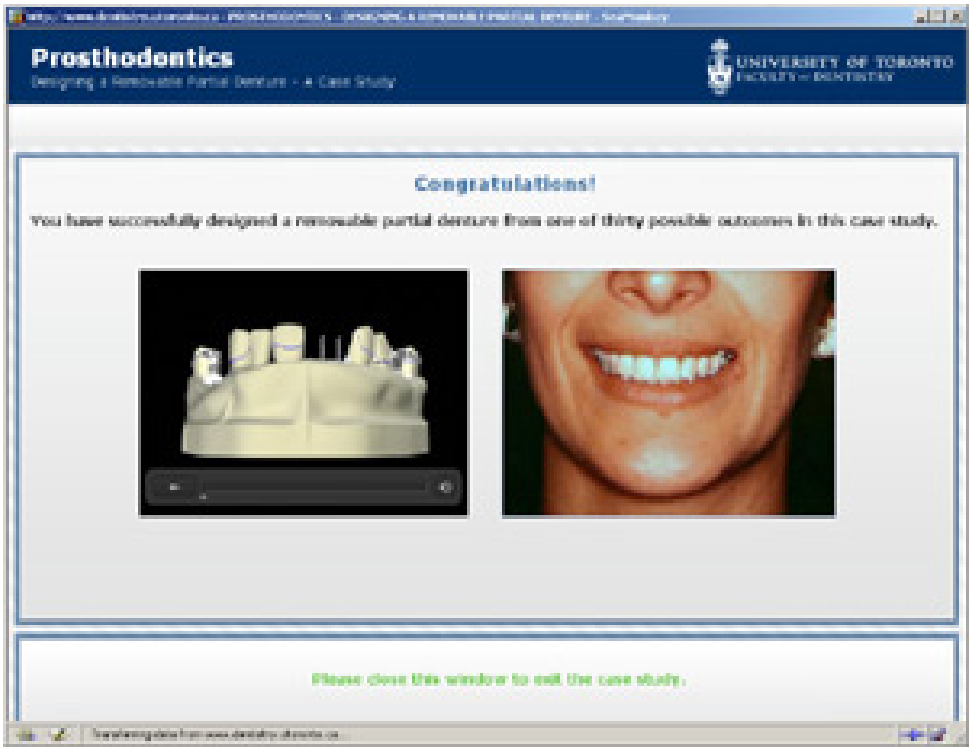

Figure 4: Completion screen in the e-learning module, showing an animation of the designed cast and an actual photo of the case-study individual

Future revisions of the e-learning module will entail the incorporation of built-in tracking tools in order to capture real-time data about the interaction of the students with the content. This will enable the authors to evaluate objectively the effectiveness of the module in ways that are not possible at the present time.

2. Experimental design

2.1 Students involved

162 students were grouped according to their year of dental studies (66 second-year students and 96 third-year students) within the discipline of Prosthodontics at the Faculty of Dentistry, University of Toronto. Previous training for the students consisted of the traditional Socratic approach, including lectures, seminars, and laboratory pre-clinical hands-on exercises. At the time of testing, the only difference between the second- and third-year students was that the third-year students had an additional year of dental training in comparison with the second year students, but had no additional Prosthodontic training. As a result, this exercise acted as a review of RPD design principles for the third-year students prior to their continued Prosthodontic training involving clinical cases with greater complexity than those encountered in their second year of training. In addition, approximately one-quarter of the third-year students (28) had previously been trained to be dentists in countries remote

from Canada and the United States of America. They were pursuing the Canadian dental program in order to become licensed to practise in Canada. English was not their mother-tongue.

2.2 Case presentation

All the students were given a case history of the same individual patient. One half of the class (designated P1P2 or Group A) was instructed to design an RPD using the traditional approach with dental models that could be touched and seen. The models consisted of actual representations of a patient's maxillary arch, including teeth, gums, and palate. The students were asked to survey the casts to determine the most appropriate tilt, a necessary step for the appropriate path of insertion of the final RPD. When finished, various treatment options, designs, and choices of materials were discussed. The other half of the class (designated C1P2 or Group B) saw the same model in animation *via* the computer-based online interactive e-learning scenario. Choices of design features and materials were made in a particular orderly sequence as outlined above in the section describing the e-learning module. All the students, whether in the P1P2 group or the C1P2 group, were given a pre-test questionnaire to complete which concerned their design choices, order of design, and learning experiences. For the subsequent and formal exercise which tested for competency with respect to RPD design, all the students were asked to design an RPD for a different but similar case using dental models in the traditional, clinically-related manner. Their work was graded by two independent Prosthodontic examiners who had previously been given guidelines of correct responses to ensure calibration. Post-test questionnaires were given to the students to assess the effectiveness of the method of their pre-test technique, in addition to their enjoyment of the approach. In order to allow all students to have the same experience using the e-learning approach, a cross-over situation followed one week later, whereby each group of students went through the alternate approach from the previous session. In other words, those originally in the C1P2 group became the P3P4 group, and those in the P1P2 group became the C3P4 group.

2.3 Pre- and post-test questionnaires

The questionnaires were designed to assist in the development and use of technology in teaching and learning in the Prosthodontic discipline in the Faculty of Dentistry, University of Toronto. Of particular interest, were the students' thoughts, feelings, and actions as well as their expectations regarding the use of technology in teaching and learning. The questionnaires were intended to be confidential. The students were asked to provide their student numbers in order to merge the pre-test questionnaire data with their post-test questionnaire data. The results were summarized reflecting the group and not any individuals. Students were instructed to circle the appropriate number from 1 to 5 where 1 represented "not at all" and 5 represented "very much so".

2.4 Objectives

The module was designed to reinforce the students' basic knowledge of RPD design principles such that that they would be able to adapt these concepts to their individual patient needs. In doing so, the students would not only be able to implement fundamental guidelines when designing RPDs but also to identify individual clinical situations where guideline modifications would be necessitated. In addition, the exercise provided a review of RPD design principles for the third year students.

3. Results

3.1 Pre-test results

A total of 66 second-year and 96 third-year dental students participated in the exercise. The percentage of third-year students from each of the groups responding favourably to individual questions of the pre-test questionnaire is listed in Table 1 below. Similar percentages were obtained from the second-year students (results not shown). Students were asked to what extent they learned something in designing the RPD in the first Case Study (Qu2). For those students who performed the e-learning exercise first (C1P2), 83.7% responded in a positive manner, whereas only 36.9% of the students who performed the test in the traditional manner first (P1P2), responded favourably. Similar results were seen in the cross-over portion of the study, where 71.4% of the students in the C3P4 group responded positively but only 17.7% did in the P3P4 group. When asked to what extent they thought that the method used in the first Case Study would help them in the design of an RPD for a similar second Case Study (Qu3), 95.2% from the C1P2 group responded favourably, whereas only 64.2% of the P1P2 group did. While 77.5% of the C1P2 group and 84.8% of the P1P2 group felt that

the tactile sense of holding a model was important to them in designing an RPD (Qu4), when the cross-over exercise was conducted a week later, 85.7% of the C3P4 group and 77.4% of the P3P4 group felt that the tactile sense was important. For the question Qu6 asking to what extent the students would prefer to design an RPD having a model to hold *versus* a digitized model, 71.5% of the C1P2 group responded favourably, whereas 91.3% of the P1P2 group did. It is noteworthy that at the cross-over exercise, 100% of the students were in favour of having a model to hold. Questions 9 and 10 assessed the students' level of comfort with respect to computer technology.

Table 1: Percentage of third-year students with positive responses to pre-test questionnaires (N=96) During the crossover session, group C1P2 (N=48) became P3P4 and group P1P2 (N=48) became C3P4

Group	Qu1	Qu2	Qu3	Qu4	Qu5	Qu6	Qu7	Qu8	Qu9	Qu10
C1P2	83.7	83.7	89.8	77.5	79.5	71.5	63.0	87.6	83.7	85.7
P1P2	93.4	36.9	93.5	84.8	87.0	91.3	63.0	86.9	93.5	87.0
P3P4	94.0	17.7	64.7	77.4	94.1	100.0	53.0	64.7	94.1	70.5
C3P4	85.7	71.4	95.2	85.7	76.2	88.1	71.3	78.6	85.7	73.8

- Qu1: To what extent did you enjoy designing the RPD in the first Case Study?
- Qu2: To what extent did you learn something in designing the RPD in the first Case Study?
- Qu3: To what extent do you think that this first Case Study would help you in the design of an RPD for a similar second Case Study?
- Qu4: To what extent is the tactile sense of holding a model important to you in designing an RPD?
- Qu5: To what extent is the visual sense of seeing a digitized model important to you in designing an RPD?
- Qu6: To what extent would you prefer to design an RPD having a model to hold versus a digitized model?
- Qu7: If a model could be scanned into a program, how likely would you be to design an RPD using an electronic program rather than by the traditional approach, using a model?
- Qu8: To what extent would you prefer a different approach in RPD design to the one used in the first Case Study?
- Qu9: To what extent are you comfortable using a computer?
- Qu10: To what extent are you comfortable studying from a computer screen?

3.2 Post-test results

The percentage of third-year students from each of the groups responding favourably to individual questions of the post-test questionnaire is listed in Table 2 below. Similar percentages were obtained from the second-year students. In response to Qu3 with respect to the method of designing the RPD, almost all of the students (91.9% from the original group and 95.1% from the cross-over group) preferred the e-learning method to the traditional one (78.3% and 76.5%, respectively). The visual sense of seeing a digitized model became very important to the students for their RPD design sequence once they comprehended what a digitized model represented.

Table 2: Percentage of third-year students with positive responses to post-test questionnaires (N=96)During the crossover session, group C1P2 (N=48) became P3P4 and group P1P2 (N=48) became C3P4

Group	Qu1	Qu2	Qu3	Qu4	Qu5	Qu6	Qu7	Qu8
C1P2	89.8	77.5	91.9	81.7	85.7	65.4	100.0	73.4
P1P2	87.0	86.9	78.3	89.1	71.7	78.3	89.1	70.5
P3P4	70.6	88.3	76.5	88.2	82.4	82.4	100	88.2
C3P4	87.8	78.1	95.1	80.4	68.3	87.8	92.7	83.0

- Qu1: To what extent did you enjoy designing the RPD in the second Case Study?
- Qu2: To what extent did you learn something in designing the RPD in the second Case Study?
- Qu3: To what extent did you prefer the method of designing in the first Case Study to the one in the second Case Study?

- Qu4: Did you learn more from the first Case Study than the second one?
- Qu5: Did you learn more from the second Case Study than from the first one?
- Qu6: To what extent is the tactile sense of holding a model important to you in designing an RPD?
- Qu7: To what extent is the visual sense of seeing a digitized model important to you in designing an RPD?
- Qu8: To what extent would you prefer to design an RPD having a model to hold versus a digitized model?

3.3 Competency test results

Grading results from the summative assessment of both the second- and third-year students are included in Tables 3 and 4, respectively. In both cases, higher grades were received by those students who performed the e-learning test prior to the competency test in comparison to those who completed the traditional approach first. Similar results occurred in the crossover session. Also included in Table 4 are the results from the competency test that the current third-year students performed during their second-year of training, without assistance of the e-learning module. Since the group of 28 foreign-trained dentists had not joined the group at that time, the number of students is 68, rather than 96.

Table 3: Summative assessment based on competency results of second-year students (N=66) during the crossover session, group C1P2 (N=33) became P3P4 and group P1P2 (N=33) became C3P4

Group	A-	B+	B	B-	C+
C1P2	14 (21.2%)	12 (18.2%)	7 (10.6%)	0 (0.0%)	0 (0.0%)
P1P2	9 (13.6%)	11 (16.7%)	10 (15.2%)	2 (3.0%)	1 (1.5%)
P3P4	13 (19.7%)	10 (15.2%)	5 (7.6%)	3 (4.5%)	2 (3.0%)
C3P4	14 (21.2%)	11 (16.7%)	3 (4.5%)	5 (7.6%)	0 (0.0%)

Table 4: Summative assessment based on competency results of third-year students (N=96) during the crossover session, group C1P2 (N=48) became P3P4 and group P1P2 (N=48) became C3P4

Group	A+	A	A-	B+	B	B-	C+	C	C-
C1P2	1 (1.0%)	4 (8.3%)	7 (14.6%)	16 (33.3%)	8 (16.7%)	7 (14.6%)	3 (6.3%)	2 (4.2%)	0 (0.0%)
P1P2	1 (1.0%)	1 (1.0%)	2 (4.2%)	7 (14.6%)	18 (37.5%)	12 (25.0%)	4 (8.3%)	3 (6.3%)	0 (0.0%)
P3P4	0 (0.0%)	18 (37.5%)	13 (27.1%)	7 (14.6%)	8 (16.7%)	2 (4.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
C3P4	1 (1.0%)	6 (12.5%)	13 (27.1%)	16 (33.3%)	8 (16.7%)	4 (8.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Second-year results (N=68)	1 (1.5%)	1 (1.5%)	4 (5.9%)	4 (5.9%)	5 (7.4%)	14 (20.6%)	3 (4.4%)	12 (17.6%)	24 (35.3%)

4. Discussion

Results from this novel approach to reviewing the concepts of RPD design indicate that the experience obtained from the e-learning sessions was a positive one that was enjoyed by the majority of the students, whether in second- or third-year of their dental training. The students were impressed by the interactive nature of the e-learning approach, particularly the ability to rotate the cast and to visualize the clasp design in a step-by-step manner. At least 83.7% of the students were comfortable using a computer, but only 70.5% of them were comfortable studying from a computer screen. Although only 65.4% of the group of third-year students who were introduced to the e-learning scenario first, did not initially feel that the tactile sense of holding a model was important to them when designing an RPD, in comparison to 78.3% of them who only had a model to hold, touch, and rotate

during the exercise, over 82.4% of the students in the crossover session felt that holding a model enhanced their ability to design an RPD. This would indicate that even though the e-learning approach may provide a valuable teaching tool, that the basic tactile sense is nevertheless important in the design process. The blended approach introduced in this study underscores the inherent value of different teaching presentations of RPD design concepts allowing students to visualize an RPD design more readily. The interactive nature of this blended approach may make the principles of RPD design, so difficult in the past for students to master, not such an onerous task after all, as some students may initially think.

5. Conclusions

A unique blended learning experience was presented to second- and third-year undergraduate dental students at the University of Toronto. The salient features of RPD design, fundamental to the discipline of Prosthodontics, were reviewed and underscored in both the traditional manner using patient models as well as through the advances of computer-assisted learning. As determined by summative evaluation, the study has reinforced the notion that today's students are technologically-literate, yet are capable of understanding the principles of RPD design traditionally difficult to master. They can design clinically acceptable RPDs using a blended approach of e-learning and traditional methods. The project has shown that the students not only enjoyed but appreciated the opportunity to do so.

Acknowledgements

Funding for this project was made possible by the Bertha Rosenstadt Endowment and the Faculty of Dentistry Endowment. The authors wish to thank the following contributors to the design process: Andrea Cormier, Neil Darbyshire, Sergey Uss, Usama Al-Rhiahi, Matthew Dang, and Greg Mount.

References

Applegate, O.C. (1960) "The rationale of partial denture choice", Journal of Prosthetic Dentistry, Vol 10**,** pp: 891-907.

Beaumont, A.J. and Bianco, H.J. (1989) "Microcomputer-aided removable partial denture design", Journal of Prosthetic Dentistry Vol 62, pp: 417-421.

Beaumont, A.J. (1989) "Microcomputer-aided removable partial denture design: the next evolution", Journal of Prosthetic Dentistry Vol 62, pp: 551-556.

Hammond, P., Davenport, J.C., and Potts, A.J. (1993) "Knowledge-based design of removable partial dentures using direct manipulation and critiquing", Journal of Oral Rehabilitation Vol 20 pp: 115-123.

Kennedy, E. (1923) "Partial denture construction". *Dental Items of Interest*, Vol 47.

Lechner, S.K., Lechner, K.M., and Thomas, G.A. (1999) "Evaluation of a Computer-Aided Learning Program in Removable Partial Denture Framework Designing", Journal of Prosthodontics Vol 8, No. 2 (June), pp 100-105.

Lechner, S.K., Thomas, G.A., and Bradshaw, M. (1998) "An Interactive Multimedia Solution to Learning Removable Partial Denture Design", Journal of Prosthodontics Vol 7, No. 3 (September), pp 177-182.

Lindquist, T.J., Clancy, J.M.S., Johnson, L.A., and Wiebelt, F.J. (1997) "Effectiveness of Computer-Aided Removable Partial Denture Design", Journal of Prosthodontics Vol 6, No. 2 (June), pp: 122-127.

McGarry T.J., Nimmo, A., Skiba, J.F., Ahlstrom, R.H., Smith, C.R., Koumjian, J.H., Arbree, N.S. (2002) "Classification system for partial edentulism", Journal of Prosthodontics Vol 11, No. 3 (Sept.), pp: 181-193.

Wicks, R.R.A. and Pennell, M.E. (1990) "A computer assisted design guide for removable partial denture frameworks", Dental Practice Vol 6, pp: 51-53.

