Implementation and Empirical Evaluation of a Case-based, Interactive e-Learning Module with X-ray Tooth Prognosis

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Abstract: The prognosis estimation of teeth based on radiographs is a subordinate but relevant target in many dental medicine curricula in Germany. Empirical data on the integration of e-learning material into dental curricula are rare. We aimed at developing and implementing a radiological pillar diagnostics online-course in the dental curriculum at the University of Witten/Herdecke. This online course was developed on the CASUS web-based learning platform and implemented in a blended learning approach. Results showed an easy creation of learning cases (virtual patients), higher utilization for the intervention group regarding the number of cases revised, time-on-task, and student acceptance. Dental students experienced improved learning efficacy, higher long time knowledge retention and significantly better results in case based assessment. The usability of the CASUS learning Platform therefore can be regarded as high and further studies using this e-learning approach are recommended.

1 INTRODUCTION

e-Learning and blended learning play an increasing role in dental education. Recent studies already showed that the integration of an e-learning course in the sense of blended learning can be both effective and efficient (Karamizadeh, 2012; Kavadella, 2012; Pokieser, 2009). In this combination, the specific advantages of both forms (spatial and temporal independence, web-based communication possibilities, direct exchange of experience, roll-playing and personal encounters) are optimally utilized (Wimmer, 2012). This is also reflected in the usage of computerized virtual patients to gain clinical competencies and diagnostic reasoning which is increasing within the last decade (Cook et al., 2010).

The planning of dentures is an essential component of the dental prosthesis customer and is carried out based on various parameters. In addition to a thorough medical history, clinical examination and radiographic diagnostics are of crucial importance. For the prosthetic planning, single tooth images have the highest value due to their precise representation (see Figure 1). Using this imaging technique, the dentist can link and interpret the clinical picture with the radiological image. Before manufacturing new dentures, problems can be detected and corrected if necessary.

Figure 1: Single tooth images from an x-ray.

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The prosthetic evaluation of the teeth shows several difficulties, such as the periodontal (Dannewitz, 2006) or the endodontic situation of the tooth, but also the coronal situation with possible fillings or caries. As complex as the findings can be, the radiological findings and interpretations are not trivial.

At Witten/Herdecke University radiological diagnostics is taught to the dental students mainly during the compulsory course "Radiology" with theoretical and practical parts in the 4th and 5th term. The knowledge obtained here will be examined by a written exam at the end of the 5th term. Radiological diagnostics is then deepened during the 7th and 8th semesters during the lectures "Dentistry Surgery", where the focus is in the area of surgical teaching contents.

The prognosis estimation of teeth using x-ray images is a goal of prosthetics, which is underrepresented in many dental medicine curricula in Germany but which nevertheless is relevant in dental practice. Empirical data on the integration of e-learning courses into dental curricula are rare.

Thus, the aim of this work was to develop an e-learning course and the integration into the local dental curriculum. Therefore, in this study the implementation was performed in dentistry and the success proved by empirical evaluation.

2 MATERIAL AND METHODS

For the new e-learning course, 55 short case studies on radiological pillar diagnostics were generated on the web-based learning platform CASUS® (Fischer, 2000). CASUS contains a platform independent, web-based authoring tool that allows to create multi-media, interactive virtual patients without the need of coding-competencies of the authors. All processes like authoring, learning and evaluation are done in the same database to ensure ease of access and high usability. The cases and media are presented in html4, all actions (results, time, feedback) are logged in the database to enable individual and overall feedback. To prevent cognitive overload the cases use scaffolding but allow a huge variety of item formats.

2.1 Implementation

The cases were always divided into three tasks: anamnesis (judging the medical history), diagnosis (finding the reason of the problem) and prognosis assessment (estimating the healing process) using an X-ray image. This step of a forecasting estimation is a learning goal which has not yet been taught in the curriculum in this form beforehand.

The course content was decisively determined by the dental radiographic findings. Radiological findings were always assigned to a diagnosis. In the collection of X-ray images and later in the creation of the learning cases, the most common dental diagnoses were integrated into the CASUS program by at least one case study. Due to the rarity of some diseases or malformations, it was not yet possible to insert all X-ray findings as a learning case in CASUS. However, later completion is possible. All cases were examined professionally by the senior physician of the dental prosthesis at the WHU.

Each virtual patient consisted of three learning cards. The first card started with the anamnesis and the clinical examination of the patient presented as a case history in text form (see Figure 2). Subsequently, the student was asked to examine the X-ray image and mark the correct answer in the long menu. The X-ray image can be increased in its size in CASUS without significant loss of quality. For reasons of data privacy, the use of panoramic film recordings was dispensed and only single tooth recordings were used.

On the second card, the student firstly received the correct X-ray findings and then was asked to make a diagnosis. The response possibilities were selected on card 1 and 2 from a selection list called "long-menu" which was arranged alphabetically (see Figure 3) into a drop-down menu and the search for the terms is arranged via an active field, which precedes the drop-down menu (Schuwirth, 1996).

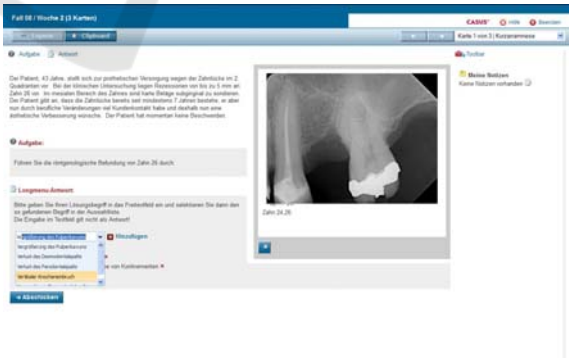

Figure 2: Screenshot Card 1 (in german) with selected X-ray findings and opened long-menu.

In the active field, it was possible to include the answer itself, restrict the selection by typing the initial letter with auto-completion, or search for the correct answer in the list. While on card 1 all possible X-ray findings were stored in the

corresponding long-menu, on card 2 all possible dental diagnoses are available. i.e. concrement, concussion or contusion. Finding of a diagnosis was not limited to a primary diagnosis, however individual diagnoses for the virtual patient were required. As a result, a diagnosis could be assigned to every X-ray examination.

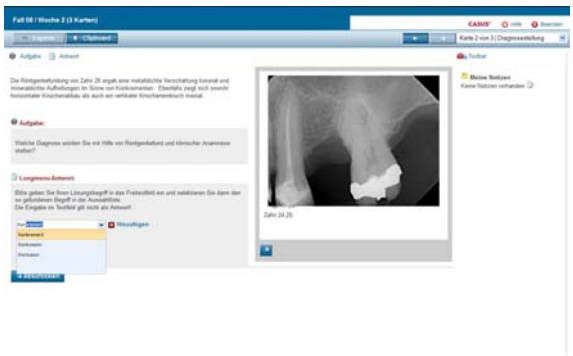

Figure 3: Screenshot Card 2 (in german) with opened long-menu.

The third card contained the correct diagnosis and prognosis assessment with four possible answers. Here, the student has to make the estimation of the tooth. The four subdivisions of the prognosis assessment were designed in accordance with the four criteria of the California Dental Association (CDA, 1977). The CDA criteria were originally used to assess the quality of dentures. They are divided into "excellent", "acceptable", "must be corrected" and "must be re-established immediately". The subdivision used in CASUS in the estimation of the prognosis was used in "Tooth-free prosthodontically usable"; “If necessary, extend prosthetics", "tooth cannot be used prosthetically" and "tooth must be removed (immediate action)". In this question, the student could choose only one answer option. After answering all three cards, a summary of the learner's success concerning the anamnesis (Card 1), diagnostic analysis (Card 2), and prosthetic prognosis (Card 3) shown in percent is provided (see Figure 4).

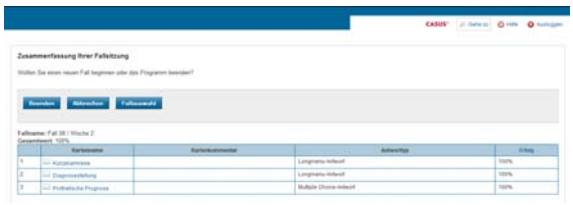

Figure 4: Summary of the learning experience (screenshot of the CASUS learning platform (in german)).

In our study approach, 30 dental students of the 6th semester (intervention group, IG) and 30 students of the 8th semester with more knowledge and experience in radiological diagnostics. (historical control, CG) were offered these case examples. Students of the 6th semester were selected as IG, because at this point they have acquired a basic knowledge, but have not yet begun dental patient treatment. The IG has been successively opened cases and addressed during the course to the content (blended learning). The CG could use all cases for self-controlled learning. Both groups were able to send questions by email to a clinical tutor.

The case-based knowledge of the volunteers was recorded formally at the beginning and end of the summer semester 2011 as well as one year after the intervention. Indicators for the successful implementation were the number of case processing, time-on-task, acceptance and success of the case processing. Figure 5 shows the flow chart of the study.

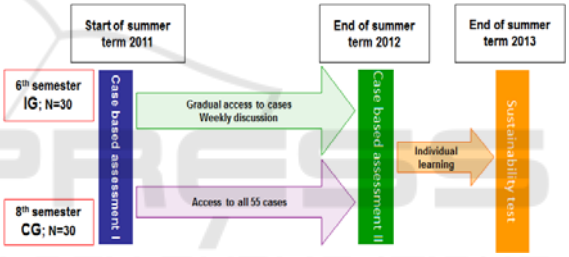

Figure 5: Flow-Chart of the course of the study.

2.2 Empirical Evaluation

It is discussed that some of the subject-specific knowledge is linked to the success of the study (Ferguson, 2002; Frischenschlager, 2005). To check whether there are performance factors such as A levels, pre-physics, physics, computer use, use of e-learning for learning, computer safety, and CASUS usage problems with higher performance Post-test, these factors were questioned in a questionnaire. In addition, age was asked as an independent variable.

To test the comparability of both groups, a pre-test was performed. In the pre-test, consisting of 5 case studies a maximal score value of 15 points (3 points per case) could be archived by the students.

Statistical analysis included univariate between group comparisons with a significance level of α=0.05. All statistical analyses were performed with SPSS 23.0.

3 RESULTS

As a first result, it was found that none of the performance factors (e.g., physics survey) correlates with the results of the pre-, post- and sustainability tests. This result reflects the current scientific research, which also rarely resulted in significant results between studies and prior knowledge in studies with a larger number of participants (Ferguson, 2002, Frischenschlager, 2005).

In the pre-test, consisting of 5 case studies, the CG was significantly better ($p = 0.015$). The CG reached 6.7 (SD 2.4) while the IG only summed up to a mean of 5 points (SD 2.1). Despite the knowledge advancement of the CG, the IG was significantly superior in the post-test, again consisting of 5 case studies ($p=0.008$). In the post-test the IG achieved 8 (SD 2) out of 15 points and the CG scored lower with only 6.2 points (SD 2.5). In the sustainability test, again consisting of 5 case studies, the IG again was significantly superior with 9.9 points (SD 1.9) compared to the CG with 8.6 points (SD 2) ($p = 0.019$).

IG moreover shows higher utilization regarding number of cases revised, time-on-task, and student acceptance. They experienced improved learning efficacy, higher long time knowledge retention and significantly better results in case based assessment. The usability therefore can be regarded as high.

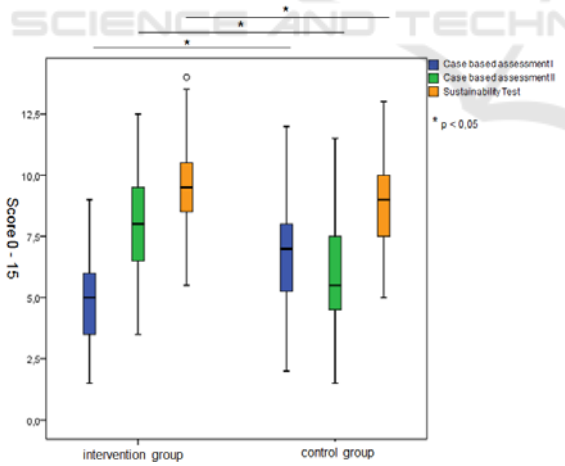

Figure 6: Score values of the intervention and control group.

4 DISCUSSION

The course concept developed for this work includes a curricular gap in dental education for the integrated mediation of radiological pelvic diagnostics. Which students benefit above all from the described teaching / learning offer? At least in this examined sample, there was no correlation between past academic performance (mirrored, for example, in physics notes, final school grades) and the results of the knowledge tests. Just as little led to a more comprehensive pre-education (already completed studies, vocational training) to a better performance. This is in line with other studies which, even in studies with a larger number of participants, were rarely able to show significant results between learning success and prior knowledge (Ferguson, 2002, Frischenschlager, 2005). However, it is described in the literature that it is particularly powerful students with an appropriate prior knowledge that benefits more from e-learning than performance-weaker peers (Grasl, 2012; Issing, 2002). Grassl and colleagues (2012) showed that students with little prior knowledge of front-end teaching benefit more than blended learning, while students with greater prior knowledge benefit more from blended learning. As the students acquire more knowledge with each course of learning, those with an initially low level of prior knowledge of blended learning will also benefit.

The advantages of integrating an online course into a compulsory course in the sense of a blended learning as opposed to the non-moderated, self-controlled learning reflected the findings of recent scientific investigations. With the new development of the course, it was possible to provide the student with knowledge of the radiological prognosis before the independent patient treatment in the clinical study section. Further studies could examine the transfer to other sites, examine the sustainability of what has been learned and ultimately examine the extent to which a positive effect on patient treatment can be assumed.

With the development of the case-based e-learning course for radiological pillar diagnostics, an easy to use and helpful supplement to the regular dental medical curriculum was created. The integration of the course into a presence event has proven itself. A direct and medium-term learning effect, also in comparison to the CG, could be shown. It is advisable to locate the course after the dental radiology course. The teaching course of the dental prosthesis does not seem to be a prerequisite and can run parallel to the course. This course can be integrated into the dental curriculum of other universities.

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