

## USE OF THE OPENLABYRINTH SOFTWARE FOR AUTHORIZING VIRTUAL PATIENTS IN DENTAL MEDICINE I

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### Abstract

The development and use of virtual patient software interests more and more universities that come together and work together, thanks to the Internet to exploit the best tools and share their progress. Among the existant virtual patient software OpenLabyrinth was selected for authoring patients. First the possibilities offered by the software are presented, then two virtual patients were authored for exemplification, and described with their limits and challenges in the two parts of the present article.

**Key words:** virtual patient, OpenLabyrinth, educational software

### INTRODUCTION

The development of computers and especially the spreading of portable devices have made education inseparable from these technological advances. PowerPoint presentations have replaced explanations on the black board, note-taking is now readily available on laptops, course materials are accessible on university platforms and all additional information can be found or obtained on the Internet. In this context of increasingly rapid virtualization, sharing and propagation of data, it is necessary to update and rethink the tools of medical training. Virtual libraries are now well developed, scientific journals have a full digital version

and there are explanatory videos in many disciplines. In this continuity, we are now considering the development of simulations in the field of health education, from simple scenarios in the form of text, to the device of augmented reality.

The support of information has greatly evolved in the course of human history with significant events since the first oral transmissions, starting with the appearance of writing, from hieroglyphs to alphabet. Secondly, the invention of the printing press was a revolution and made it possible to disseminate information widely and at lower cost. It is towards the end of the XIXth century that the information is

detached from the physical support with the telephone (1876), the radio (1901) and the television (1926). Then in 1970 the first computers and the first computer networks appeared, and finally in 1992 CERN introduced the WWW (world wide web) servers which opened the doors to the era we know today [1].

The first "machine to teach" is surely the *Drum Tutor* of the American psychologist Sydney Pressey. It is a sequential machine that requires to go through a chain of operations to obtain the information [2]. Today, mannequins or computers are used to develop medical simulations.

Simulation pedagogy in dental schools has undergone a significant evolution over the last thirty years. Although the use of virtual patients is relatively new in dental education, the use of simulated patients, in combination with laboratory data, for diagnosis and treatment plan, was used as early as 1990.

In 2000, the European Commission validates the action plan "E-learning, thinking about the education of tomorrow". It is part of the eEurope Global Action Plan which "aims to enable Europe to exploit its strengths and overcome the obstacles to the integration and increased use of digital technologies" [3].

The Haute Autorité de Santé defines health simulation as "the use of a material (such as a manikin or a procedural simulator), virtual reality or a standardized patient to reproduce situations or environments of care, in the purpose of teaching diagnostic and therapeutic procedures and of repeating processes, medical concepts or decision-making by a health professional or a team of professionals" [4].

Virtual patient simulation (PV) makes it possible to present, using scenarios, realistic clinical cases in which the learner seeks to obtain all the information necessary to establish a diagnosis and to propose a

therapeutic management [5]. Emphasis is placed more on the skills of thinking, logic and application of knowledge than on purely practical skills.

The Virtual Patients simulations are a mandatory learning instrument especially in some university clinics with limited possibilities and resources. They can constitute a bridge through the real clinical situations, familiarizing the future dentists with different situations, techniques and technologies otherwise difficult to access.

The development and use of educational software in general, virtual patient software, in particular, interests more and more universities that come together and work together, thanks to the Internet in order to exploit the best tools and share their progress [7], [8], [9].

A wide variety of commercial and open-source VP systems, such as vpSim, Web-SP, MedSims, CASUS, CAMPUS, OpenTUSK, OpenLabyrinth, or i-Human are available and applied in health care education [10], [11].

## THE AIM OF STUDY

Among these educational software we selected OpenLabyrinth [12]. First the possibilities offered by this software are presented, then two virtual patients were authored for exemplification, and described in the two parts of the present article. The limits and challenges of this software will make also the subject of the second part of the article.

## MATERIALS AND METHOD

The first version of OpenLabyrinth was created by the Learning Technology section of the College of Medicine and Veterinary Medicine at the University of Edinburgh, but the latest versions also include the work of the Northern Ontario School of Medicine and the Aristotle University of Medicine Thessaloniki". It is an open-source system for

creating interactive educational content such as virtual patients but also simulations, labyrinth games and algorithms [13].

Access to OpenLabyrinth requires nominative credentials provided by the administrator. On the homepage, one can find all the current projects of the working group.

There are different ways to create a labyrinth. Existing models can be used by duplicating those of the group (so the original will not be modified) or by importing projects via Medbiquitous (Fig. 1).

Virtual patient creation can be:

- manual: we insert the title, a description, the keywords, the type of interface and a timer if necessary;
- step by step: the first option is the same as

in manual mode, the second one requires the type of PV (linear, branched or in pearl necklace) and the third one requires the start and the end scenarios.

This category contains the two components that make up the skeleton of a labyrinth: the rooms and corridors represented by the nodes and links.

The visual editor (Fig. 2) is the schematic representation of the labyrinth. It allows the creation of nodes and links that form the labyrinth structure.

One can modify the content of the nodes (title, text, image, multimedia) and their characteristics (priority, mandatory). One can also establish links between the different nodes, represented by arrows.

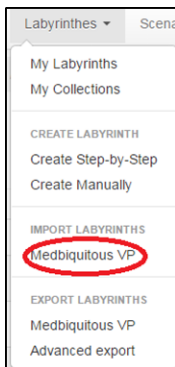


Fig. 1

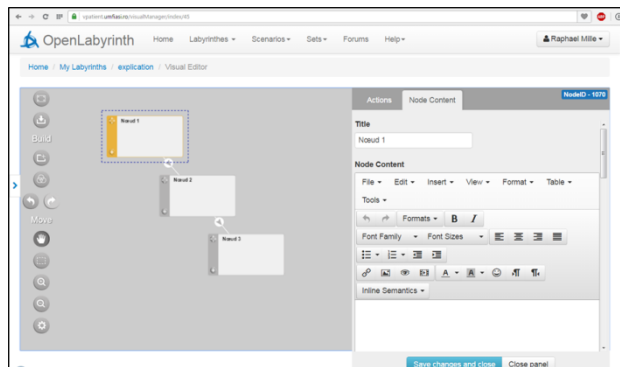


Fig. 2. This labyrinth has three nodes with a link, represented by an arrow, going from node 1 to node 2 and a link from node 2 to node 3.

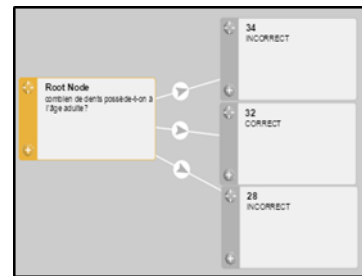


Fig. 3. Question created with nodes and links

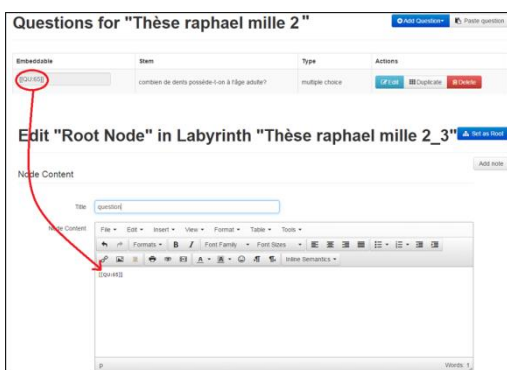


Fig. 4. Inserting the marker in the node

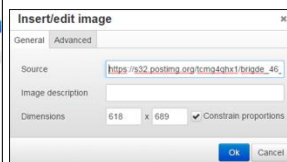


Fig. 5. Image editor

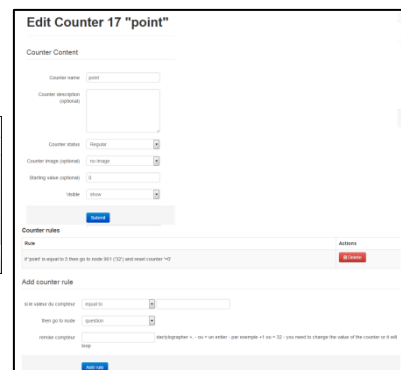


Fig. 6. Counters

Nodes are the units of the labyrinth and contain what the user will see when exploring as a "card". It is important to

understand that, for example, "node 1" contains all data relating to "card 1".

They can be exploited either with the visual editor or with the menu of the nodes. There is the possibility to add (add a node), modify their content (direct), delete (delete) and preview of the final rendering (view). The option to edit links is also present. Nodes are the representation of the situations through which the user will travel during the execution of the scenario.

The link is what connects one node to the other. There are different types (hypertext link, drop-down menu, text to enter) but the easiest to use and create, is the button which the user will only have to click to proceed to the next node. In addition, links can be one-way or two-way.

The linker allows to visualize the different links uniting the nodes, to modify them or to add them.

Options allow the creation and integration of items within nodes, questions, illustrative objects, and counters.

The virtual patient software allows to question the user whether it is for learning or for evaluation. We can proceed in two ways:

- Without the question editor, we consider a first node containing the question, itself linked to other nodes that contain the answers. With this process, questions are necessarily simple complements.
- With the question editor, you can create questions and integrate them inside the node. There are many possible forms (text entry, multiple choices, drop-down menus, answer to order ...).

For multiple-choice questions, one sets the question and then inserts the answers by determining which ones are correct and which ones are not. One can also add a score and a comment that will appear when the user selects the answer. When the question is finished, the software creates a marker in the form [[QU: XX]] that can be integrated into the node (Fig. 4).

For other forms, text entries are easy to set for numeric values, but when one asks for written answers they must be able to anticipate all possible answers including spelling, word order and synonyms.

OpenLabyrinth does not host images and videos itself. Indeed, it is not yet possible to insert these contents directly from the local computer. It is necessary to first upload them (download on a computer or a remote server) using many websites that do this for free (<http://www.hostingpics.net>; <https://postimage.org>). Once the link of the object obtained, it is enough to copy it in the editor of image or video in the contents of the node (Fig. 5).

A point system assigned to each user's choice can be used by giving values to the different responses. The score can be purely indicative, for the evaluation of the user, or allow to lock access to certain nodes if the score is too low. Therefore, rules must be added to the "add counter rule" counter, in the form of "If the counter is equal to 5, move to node X" (Fig. 6).

These counters can also be used to quantify prices, or health indices (heart rate, blood sugar, pain).

## RESULTS AND DISCUSSIONS

The different features and options of the software were used in authoring the two virtual patients described in the two parts of the present article. For all the patients the informed consent was obtained.

The first virtual patient offers a diagnostic and treatment plan in its first part, and then the user must review the various prosthetic options and criticize the choice to make. Finally he has to face the complications.

The VP has 22 nodes, 40 links and 20 questions. The structure is also in pearl necklace. There are also three sections: (a)

anamnesis, (b) diagnosis and treatment plan, (c) prosthetic treatment and complications (Fig. 7).

The first node shows the patient picture and three choices are given: continue the anamnesis, do the intraoral exam or check the X-ray.

(a) In the *anamnesis*, the user learns that the patient has undergone radio- and chemotherapy and is asked a question related to the oral side effects of these treatments (Fig. 8) and then the next sequence continues.

The intra-oral examination reveals numerous lesions. The question raised here is related with the etiology of these lesions and thus resumes the discussion with the patient (Fig. 8). The evaluation of the metal-acrylic bridge is issued in the card 4 and supported

by the X-ray. Students tend to look at X-rays very quickly, sometimes even before speaking to the patient.

*Observations:* Note that the first node (in yellow on Fig. 7) has only one classical link while three choices are possible. To enable navigation, a counter was used, which was inserted into the first node, and assigned rules (Fig. 9). Each answer to the question "what do you do" generates a score when you click on it and this score corresponds to the next node. For the transition to the diagnosis part, the correct answer to the question of the last node ("What type of para-clinical exam would you recommend?") leads directly to the first card of the second part.

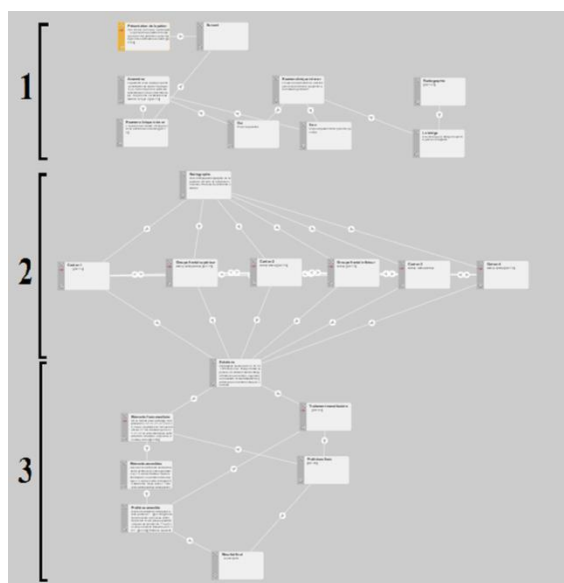


Fig. 7. Pearl necklace structure of labyrinth (map):  
1. anamnesis; 2. diagnosis; 3. prosthetic solution

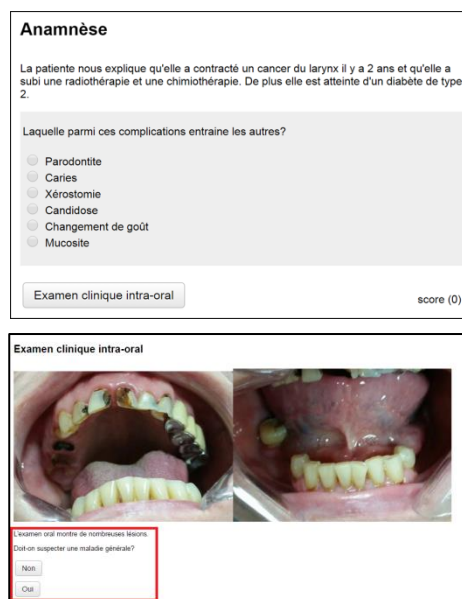


Fig. 8. Anamnesis and intra-oral clinical examination

Counter rules	Actions
Rule	
If 'score' is equal to 2 then go to node 966 ('Radiographie') and reset counter '100'	<input type="button" value="Delete"/>
If 'score' is equal to 1 then go to node 965 ('Examen clinique intra-oral') and reset counter '100'	<input type="button" value="Delete"/>
If 'score' is equal to 3 then go to node 964 ('Anamnèse') and reset counter '-3'	<input type="button" value="Delete"/>
If 'score' is equal to 4 then go to node 976 ('Radiographie') and reset counter '-4'	<input type="button" value="Delete"/>

Fig. 9. Rules of the counter

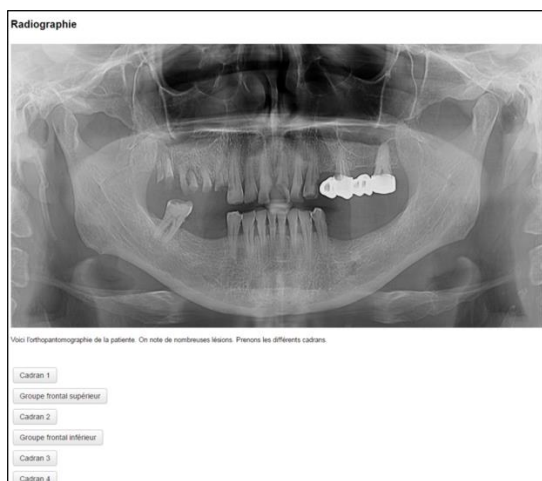


Fig. 10. OPG and quadrant selection

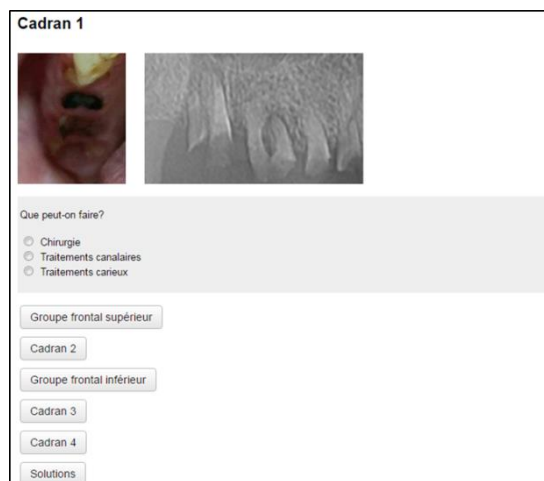


Fig. 11. Quadrant example

The advantage of this method is to avoid influencing the user in his choice of answer, in fact the classic links appear in the form of buttons and clicking on it, if the answer is wrong, leads to another node and force a backtrack.

(b) In the *diagnosis* part, each quadrant of the oral cavity was presented into a node with clinical and radiological images and a question. The first card of this part (Fig. 7) shows the orthopantomography of the patient and asks to look at each quadrant/segment. From this step one must choose from the six segments of the dental arch (Fig. 7 - cards 8, 9, 10, 11, 12, 13) and answer the questions asked. If the button "solution" is clicked on before having visited all the dental segments, a message tells us to finish the exam.

In the 1<sup>st</sup> segment (Fig. 10) remaining roots are present and the question is what should be the approach. The link to the first segment no longer appears because it has already been visited. It is the case for the each

visited node. For the anterior segment the question is related with the type of the required restoration: direct restoration (composite), indirect (bridge) or surgical. For the second quadrant, the images have already been encountered in the first part of the map if the user has chosen to view the X-ray directly (Fig. 10). We no longer look here at adaptation but the mesial extension that is always a questionable element that must be justified. In the 3<sup>rd</sup> quadrant there is an edentulous space. The images are presented for information purposes but the student should start considering a removable prosthetic solution. In the inferior anterior sector, one can note the dental and periodontal lesions (abrasion, calculus, dento-alveolar incongruence). Saving a tooth for prosthetic reasons is a complicated problem and a general perspective is needed. It will sometimes be necessary to make concessions in order to keep a damaged tooth. This is the case here because it is a terminal tooth that might ensure the stability of a removable denture.

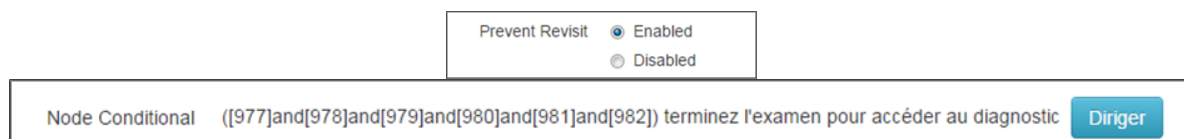


Fig. 12. Access conditions to the "solution" node

By visiting all the cards, one now has access to the last part.

**Observations:** In order not to go around in circles and return to previously visited cards, the option "prevent revisit" has been activated for the dial nodes (Fig. 12). This will no longer display the link to a card already seen. The restriction of access to the next part is done by programming the node "solution" with the option "node conditional" (Fig. 12). You must have visited the nodes 977, 978, 979, 980, 981

and 982, corresponding to the quadrant charts, to be able to continue, otherwise the message "complete the examination to access the diagnosis" appears.

(c) The prosthetic solution part begins by giving the principal directions of the treatment: surgical, fixed restoration and removable denture. One has the choice to start with the maxillary or mandibular prostheses, both having a fixed part and a removable part.

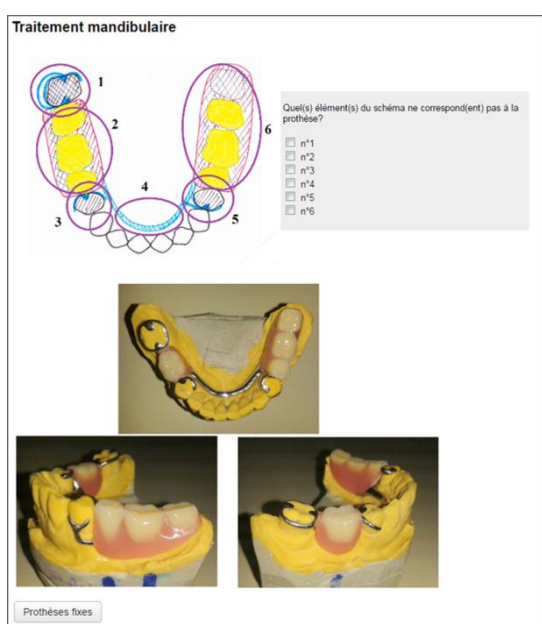


Fig. 13. Exercise of differences



Fig. 14. Exercise of differences



Fig. 15. Correspondence exercise

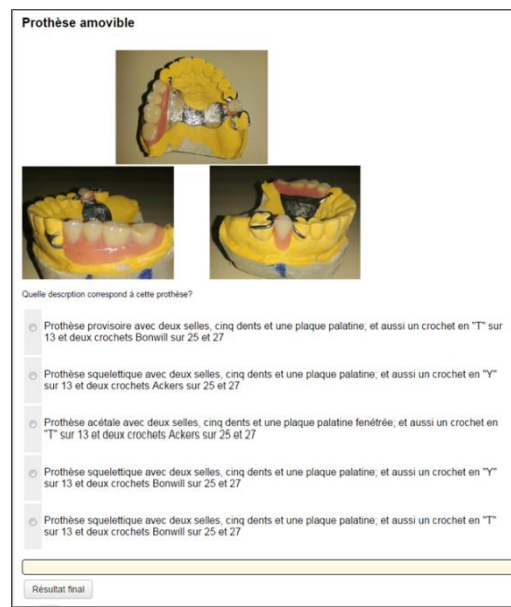


Fig. 16. Terminology exercise

For the mandible an exercise of differences between the removable partial denture diagram and the actual denture is proposed (Fig. 13). A question is asked about the utility of adding fixed elements (Fig. 14).

For the maxilla there is a question about an impression for inlay-core (Fig. card 17), then a correspondence between removable denture elements and their schematic representation (Fig. card 18) and finally it is asked to select the correct terminology to name the removable partial denture (Fig. card 19).

One can always criticize and find defects in an impression, here the absence of discharge groove been obvious, but it was decided to ask what this impression corresponds from a prosthetic point of view.

For the removable partial denture, a mapping exercise is proposed between prosthetic components and their schematic representations (Fig. 15).

The map finishes with a question of terminology (Fig. 16) where one have to select the correct definition corresponding to the restoration.

The last card can only be accessed if all cards of this part have been visited. We obtain the final result with the comparative before and after.

*Observations:* We encountered different problems for the development of the exercises. Indeed it is not possible to embed images directly into questions. It was thus necessary to create the answers independently of the questions and the images and to make a work of layout with the help of tables. Then you must know that the number of characters per response is limited, so we also had to use tables. As for the second part we used the options "prevent visit" and "node conditional".

## CONCLUSIONS

In this virtual patient, it has been worked on the attractive side. We have diversified the iconography: intra-oral clinical photographs, impressions, models, prosthesis diagrams, and types of questions: simple choices, multiple choices, correspondence exercises and differences. For the latter, the existing tools (questions, tables) have been exploited to obtain a form that is not proposed directly. The proposed themes are mostly access on the prosthetic but the questions are almost all different to avoid weariness [14]. Finally, we have optimized navigation with the options to avoid backtracking and repetition of the nodes with the conditions of access to the nodes and the "prevent revisit".

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