ImpressDent: Learning how to make dental impressions with a computer simulation

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Despite the importance of learning how to make accurate dental impressions, dental students do not currently get adequate opportunities to apply their dental anatomy knowledge to the procedure of impression-making. A computer simulation *ImpressDent* was built to allow students to test out various scenarios in order to understand the impact of different variables on dental impressions. A case study was conducted with ten dentistry students to find out what and how students learned from their interactions with *ImpressDent*. Congruent with our aim, students reported that they learned the impact of different variables on the dental impression and they identified iterative trial and error as their main learning process. The instructional design of *ImpressDent* can serve to guide educators interested in developing their students' procedural knowledge in constructivist ways. Further investigations will be undertaken to examine the impact of this learning activity on students' ability to evaluate their dental impression independently.

Keywords: computer simulation, constructivism, dental education

Introduction

The creation of accurate dental impressions is important because it directly impacts on subsequent dental procedures such as the construction of dentures. For example, inaccurate impressions will lead to inaccurate dentures, resulting in patients having to undergo the same procedure several times.

At the University of Otago, the making of dentures is currently taught in the Year 4 Bachelor of Dental Surgery degree through lectures and clinics. During lectures, teaching staff verbally explain how to make dental impressions correctly while referring to pictures and clinical photographs (e.g., incorrectly made dental impressions). Students are asked to judge how acceptable each example is. During clinics, under the guidance of clinical teachers, students are shown how to achieve an ideal impression and then tasked to repeat the same procedure independently with an actual patient. Each clinical procedure is assessed by the clinical teacher, during which students and teacher discuss the positive and negative aspects and how these might affect the final clinical outcomes.

From Ma's (author 1) experiences as a lecturer, existing learning experiences are inadequate because many students seem to struggle to apply their dental anatomy knowledge while making dental impressions during clinics. In particular, while students have descriptive/declarative knowledge of dental anatomy, they do not fully understand how the various anatomical features might impact on dental impressions. For example, while many students can describe the anatomy of the tongue, very few understand how particular tongue movements might impact on the impression during impression-making. This reflects the emphasis on declarative over procedural knowledge in most universities (Biggs & Tang, 2007).

Challenges to pedagogical changes

To redress the balance, dental education has seen a shift from traditional to competency-based education where the emphasis is now on the actual practice and demonstration of dental procedures (Yip & Smales, 2000). In the same vein, we speculate that students can most fruitfully apply their dental anatomy knowledge by going through the experiential learning cycle (Kolb, 1984): by making dental impressions and then linking particular choices made (e.g., side-to-side tongue movement) to particular features on the impression. Ideally, students would be able to iteratively test out various scenarios (e.g., activation of different facial muscles) in order to understand the impact of different variables on the dental impression. Such a learning approach would be constructivist in that students, through their iterative trial and error, construct their own meaning of the impact of different variables instead of simply recapitulate what the teacher said (Jonassen, 1996). A constructivist approach is necessary here because the making of dental impressions is a complex skill that requires adaptation to the particulars of the situation and not a simple repetition of prescribed steps (Piaget, 1970).

However, there are currently few opportunities for such experiential and constructivist learning. During the course of the year, Year 4 students have about 25 clinical sessions to practise making complete dentures for

actual patients. These clinics are typically conducted in a set time because it would be inappropriate to carry out the same procedure too many times on the patient. During each clinic, students usually get only two chances to obtain an accurate impression, after which the clinical teacher takes over. A study on confidence levels reported that final year dental students had low confidence in undertaking complete denture construction (Honey, Lynch, Burke, & Gilmour, 2011). Inadequate practice was cited as the main reason why this was the case. To increase students' opportunities for practice, we developed the computer simulation *ImpressDent*.

Description of *ImpressDent*

ImpressDent is a web-based computer simulation that allows students to tackle a number of clinical cases. Students solve cases by choosing different variables at each step in the impression-making process. An example of a step is how far the tray should be placed in the mouth (see Figure 1). A total of nine steps are simulated in *ImpressDent* (e.g., horizontal placement of tray, protrusion of tongue), reflecting the real-life considerations of tray placement, facial movement and downward pressure.

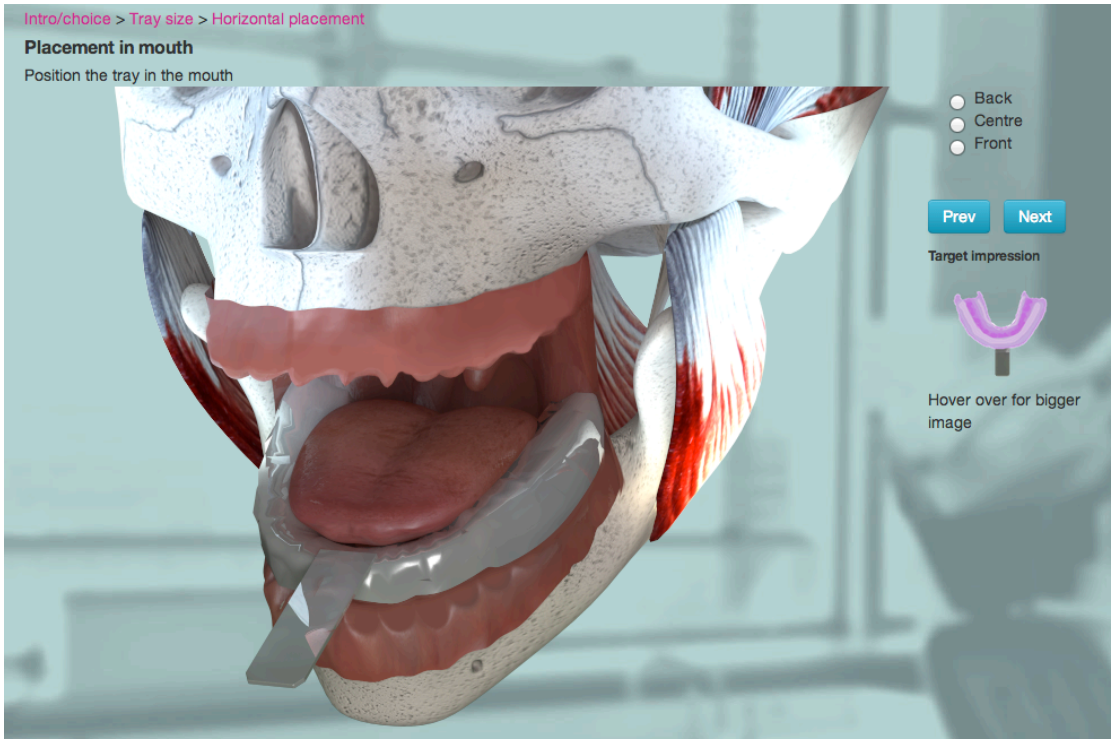

Figure 1. Students choosing how far back to place the tray in order to approximate the target impression (given in right column)

These nine steps in the impression-making process are cumulative: upon making each choice, students will be shown the corresponding image which depicts the cumulative choices made thus far. Once students finish making all nine choices, they will be shown the final impression that depicts the direct effects in the putty from the choices made. Students interpret these effects themselves by comparing the final impression with the target impression.

To solve a clinical case, students are free to undertake as many runs of the simulation as they need. Every run is logged by the system, and students can look at previous runs to review the choices they had made previously. This is to encourage students to iteratively test out their evolving hypotheses.

For more than a decade, dental educators have used many types of simulation, ranging from simulated patients in the form of manikins to virtual reality-based simulations (Buchanan, 2001). *ImpressDent* is unique in three ways: first, it focusses on impression-making while most other simulations for dental education focus on teeth preparation; second, it is a scalable solution that requires only an internet browser while most other simulations require specific and expensive hardware (e.g., manikins); third, *ImpressDent* is designed for students to make sense of impression-making themselves by having students compare their final impression with the target impression, not by providing students with the right answer.

Method

A case study was conducted with ten dental students to find out *what* and *how* students learn from their interactions with *ImpressDent*. Our aim was for students to learn the impact of different variables on the dental impression by iteratively testing out various scenarios. These fourth year students have attended lectures on making dental impressions and have also made dental impressions for at least three patients during clinics.

In a computer laboratory, the students were tasked to address Cases 1-3 within 20 minutes, without their teacher's aid. Case 1 required students to create an accurate impression for a specific patient; Case 2 was to reproduce an inaccurate impression; Case 3 offered a 'sandbox' mode where students can experiment freely. For Cases 1 and 2, the target impression was displayed to students so that they can match it with the impression obtained (see Figure 1). Students were free to undertake as many runs of the simulation as they needed within the 20 minutes.

Three sources of data were captured: observational field notes made by authors 2-4; log files that recorded all students' choices; and a post-trial focus group interview. The interview lasted 30 minutes and was fully transcribed. We searched all data sources to identify *what* and *how* the students learned from their interactions with *ImpressDent*. "Trustworthiness" (Guba & Lincoln, 1989, p. 233) of the findings was maximised by:

- triangulating multiple sources of data so that individual viewpoints can be verified against others, and self-reports can be checked against log files; and
- maintaining insider and outsider viewpoints throughout the study. Author 1 is a member of faculty (insider) and authors 2-4 are researchers from the university's academic development centre (outsider).

Findings and discussion

The ten students tackled Cases 1-3 within the 20 minutes. Students completed an average of nine runs each (ranging from six to 15 runs per student); they took an average of 1min 14sec to complete each run (ranging from 20sec to 3min 37sec per run).

In this paper, we report our early findings regarding *what* and *how* the students learned from their interactions with *ImpressDent*. When questioned about *what* they learned during the trial, students mentioned the impact of different variables on the dental impression:

> Student 6: I found it useful to see... how different parameters affect the final impression… so I've just changed one thing and then at the end I'd see how that one thing can affect the whole impression.
>
> Student 8: … it kind of also shows you how each of the [facial/tray] movements translates onto the impression in the end.

Without any facilitation from the teacher, students have begun to link particular choices to particular features on the impression. Making such links is important for students to evaluate their own impressions and to adjust their impression-making steps independently.

Besides the impact of different variables, students also learned other things such as the main steps dentists need to go through to make dental impressions (Student 5) and the main factors to consider when making dental impressions (Student 9).

When questioned about their learning *process*, students mentioned that they learned about the impact of different variables through trial and error:

> Student 1: I think sometimes you thought that there was this one thing [causing the inaccurate impression], oh well I'll change this one thing, it's all I have to do and then you realise it's actually something else that wasn't quite right.

One student also reported to have learned by "[making] mistakes" (Student 9), a learning process that would be inappropriate during clinics. It is noteworthy that their trial and error was iterative, first involving more guesswork and progressively involving more informed choices:

> Student 10: You sort of adjust one thing and then you're like, OK I'll fix that bit. And then you realise there's another bit to fix. So kind of like keep that one that you'd fixed and go through and do another change until it matches.
>
> Student 6: I just thought like *firstly* it was trial and error and *then* you could just look at the image and pick out the places you needed to improve. (emphases added)

This iterative process is resonant with constructivist learning approaches where the learner undertakes successive cycles of interactions until equilibrium is reached (i.e., when the learner's experience matches her conceptualisation).

Our field notes also concurred that students were constantly checking their understanding with their neighbours (e.g., pointing at each other's screen and commenting on each other's obtained impression), a process that is resonant with social constructivist learning approaches (Vygotsky, 1978).

Conclusion

ImpressDent, a web-based computer simulation, was built to provide more opportunities for dental students to apply their dental anatomy knowledge to the procedure of impression-making. Students reported that they learned the impact of different variables on the dental impression; they identified iterative trial and error as their main learning process. These findings are congruent with the aim of the instructional design of *ImpressDent*. The instructional design of *ImpressDent* can serve to guide educators interested in developing their students' procedural knowledge in constructivist ways.

At a later stage, *ImpressDent* will be trialled with 85 students as a learning activity to be carried out between lectures. Further investigation will be undertaken to examine the impact of this learning activity on students' ability to evaluate their own dental impression independently.

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