Rethinking preclinical training: student collaboration, developing personal 3D-printed instrument analogues, and the smartphone

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Key points

- The reader will gain insight into a different approach to clinical and preclinical training.
- The article details design and environmental considerations for tool development. This will be relevant both for those developing a tool, and for anyone considering procuring new devices.
- The reader will gain an awareness of a developing new tool.

Abstract

Research and exploration continually yield advances in technology and approaches to education. There is often a crossover between these domains, giving rise to technology-enhanced learning. The traditional trainer-imparting-wisdom-to-trainee model is no longer considered a one-way discourse. Dundee School of Dentistry has been exploring novel methods of preclinical and clinical training for quite some time and this is clearly apparent in the 4D curriculum. Key technological areas that have rapidly evolved in the past decade holding tremendous educational potential include personal digital device functionality, along with 3D scanning and printing.

This article details a trainee-trainer collaboration to update an existing 3D-printed training tool, simulating a handpiece to interface with capacitive screens.

Introduction

Training has evolved considerably from didactic, lecture-driven content, with a singular directional path of the 'trainer' imparting information to the 'trainee'. Trainees each have a unique history and learning style and a plethora of personal talents and skills.

The COVID-19 pandemic demonstrated the need to be able to adapt, improvise and evolve teaching. During this time, the committed innovative spirit and skills of our undergraduate trainees was instrumental for continuing training. Trainees reflected on how skills had been taught in the past and were open-minded on how we could modify these approaches. After working with students on several projects, it is clear that a collaborative approach is a productive way of teaching, demonstrating synthesis of knowledge.[1] One of these student collaborations catalysed the evolution of a novel training tool to interact with capacitive screens: a cost-effective link between virtual and physical realms of simulation utilising personal digital devices, ubiquitous in the student population. This article details the development process and outlines potential future applications as an example of how learning communities can create unique opportunities to enhance clinical training.

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Background

At the Dundee School of Dentistry, investigating the practicality of handpiece training tools began in 2018, in preparation for the 4D curriculum.[2] 'Pens' were produced using silicon moulds to replicate the contra-angled ergonomics of a handpiece[3] and students completed a set of activities. The students responded positively to this novel exercise and the concept was shared with the wider academic community.[4,5] Feedback was mostly positive but highlighted the production process needed to be improved for upscaling.

A refined device, modelled on a handpiece using computer-aided design software, was collaboratively produced with the Duncan and Jordanstone College of Art and Design and the Library and Learning Centre. This process allowed production of the working model in sufficient numbers for students to practice.[6]

With the COVID-19 pandemic prompting a reassessment of how training should be delivered, there was opportunity to collaborate with trainees. A few undergraduate trainees had personal interests and demonstrated a natural ability to quickly learn aspects of the processes involved in rapid prototyping. This expanded the repertoire of training tools.[7,8]

After a return to clinical training in 2021, remote and safe methods of training still warranted exploration. A project was proposed to develop a process for producing training tool analogues that can interact with capacitive screens and prove utility by creating a modified version of the 'pen' (Fig. 1).

The development process

Material selection

A clear set of realistic criteria were considered: material availability; environmental factors, such as carbon footprint; production process safety; material cost; print predictability; and compatibility with available printers. When considering materials to interface with capacitive screens, there is an additional consideration of resistivity. There are now several 3D printer filaments falling under the umbrella term of 'conductive filaments' that are specifically designed for this purpose.

With regards to environmental impact, printed thermoplastic filaments are usually not accepted as plastic waste in recycling centres due to the fact that most have a Society of the Plastics Industry resin identification code Type 7 plastic classification (for example, PLA [polylactic acid] or ABS [acrylonitrile butadiene styrene]).[9,10] PLA, the most commonly used 3D printing filament, despite claiming to be biodegradable, is only compostable in industrial conditions.[11] Using the minimum amount of material is therefore imperative.

The new device was designed as three parts:

- Non-conductive 'rotary handpiece' body
- Conductive component
- 'Bur' analogue.

For the non-conductive and conductive components, material choices were limited to those commercially available and compatible with filament 3D printers. Although there are many advantages to using resin printers, both in tool design and finish, filament printers and their associated consumables are cheaper to procure, maintain, and more likely to be available for institutions with limited budgets and resources.[12,13,14]

When selecting a 'bur', it was decided that using a commercially available stylus tip would be the best option. There are a number available for purchase online that resemble the dimensions of a bur. As this will ultimately be in contact with the capacitive screen, having a quality assured and fit for purpose component was essential.

Designing the training tool

The final design used the minimum amount of plastic. This kept costs low and most importantly, reduced the carbon footprint. Expert advice on 3D printing and product development was provided by colleagues from the Duncan and Jordanstone College of Art and Design.

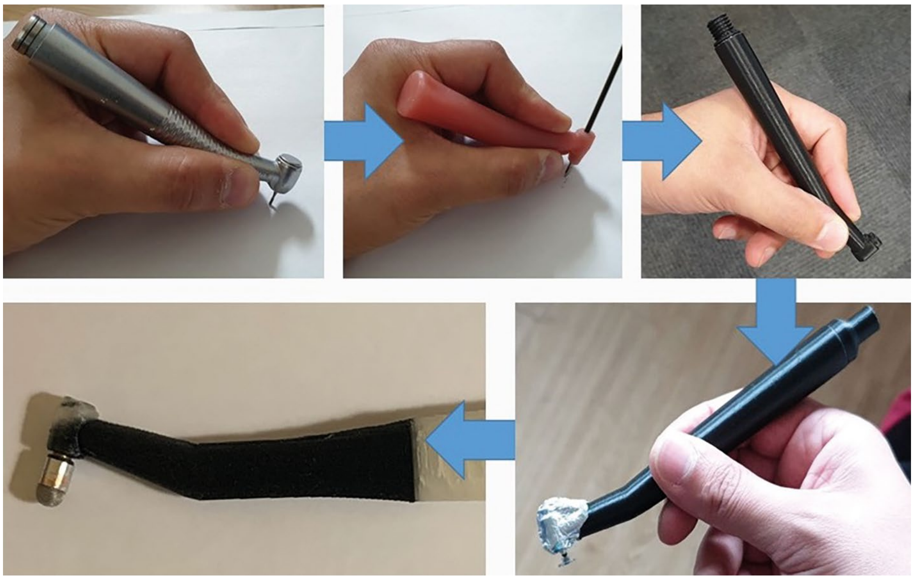

Fig. 1 Evolution of the handpiece training tool prototypes from initial work with real instrument to the 3D-printed model that functions with capacitive screens

Fig. 2 Varying prototypes investigating the balance of conductive and non-conductive materials

Safety was of paramount importance. The device would need to be robust and safe to use under normal use with a significant margin of error. Any components requiring assembly would need to securely fit together. Therefore, it was decided that the instrument would be manufactured as a single component, excluding the stylus tip. Dual extrusion printing was used to combine conductive and non-conductive components.

Ergonomically, the tool was designed to accurately replicate the angles and dimensions of widely used high speed handpieces. Several devices were reviewed before designing the tool.

Due to cost, material properties and availability, it was decided that conductive filament would be used for a minimum of the design. A balance needed to be struck, however, between minimising the amount of conductive material, but not increasing the resistance of the tool (Fig. 2). An increase in the resistance would negatively affect the ability of the tool to interact with screens. However, restricting conductive zones to areas held during normal use may help 'train' students on the appropriate grip for the real instrument.

The final elements to be considered related to the printers. Dual extrusion filament printers, such as Ultimaker,[15] have tremendous potential and countless applications, but still have limitations.[16] The print accuracy needed to be high enough to ensure secure fit of the stylus tip, intimately contacting the conductive filament components.

Once the realistic balanced criteria were explored, the design was ultimately created using Rhino software.[17] The final design was

Fig. 3 The final 3D print design

exported as an STL (STereoLithography) file (Fig. 3). This type of file can be shared easily and modified for printing across a variety of 3D printers. These files can be utilised by other institutions that may want to explore the project further with the Dundee School of Dentistry.

Discussion

Undergraduate trainees are a significant component of the heart and soul of any dental school. There has always been a spark of creation and a willingness to collaborate. As trainers and practitioners, we can facilitate unlocking this potential.

The tool created reliably works with mobile phone and tablet capacitive screens. A companion mobile application developed at the Dundee School of Dentistry, 'Defeat the Decay',[18,19,20] demonstrates the functionality of the training tool.

The tool has the potential to use several innate functions of mobile phones to enhance the learning experience. Mobile phones can also capture data and provide useful feedback to the trainees and the trainers.

The development process can also be applied to the production of other instrument analogues, allowing the student to have an array of tools to practise on their phone. This has applications across specialties.

Innovation in education and practice must also address inequality. Resources created should be shared across institutions and consideration given to whether they can be dual purposed for engagement and education of patients and families. Sharing innovations and resources can be particularly useful for enhancing training delivery in institutions that may not have access to the tools or finances to develop resources. Sharing innovations will also allow different institutions to focus on varied topics rather than creating resources that address similar topics.

The printing process and training tool have been shared with the academic community.[21]

Conclusion

By practically applying and demonstrating utility of collaborative projects, students can see the impact that they can have on the profession. As restrictions continue to ease and clinical training becomes more predictable, it is crucial that the collaborative, innovative spirit of trainees is not forgotten.

Ethics declaration

The authors declare no conflicts of interest.

Author contributions

Clement Seeballuck: lead author. Tung Hin Lau: contributing author, text relating to the project and tool development and production.

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