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## Flexible 3D-printed colon with embedded polyps for colorectal cancer public engagement

Anna Roberts<sup>a</sup> , Mark Roughley<sup>a</sup> , Melissa Rankin<sup>a</sup> , Paul O'Toole<sup>a,b</sup>  and Susan Baker<sup>a</sup> 

<sup>a</sup>Liverpool John Moores University, Liverpool, UK; <sup>b</sup>Department of Gastroenterology, Royal Liverpool University Hospital, Liverpool, UK

### ABSTRACT

Three-dimensional (3D) modelling has demonstrated value in endoscopic training by creating models that improve recognition of colorectal polyp morphology. Building on our previously published research, we aimed to explore how a research-derived 3D printed colon model could function as an alternative visual communication tool to raise public awareness of colorectal cancer (CRC), screening, and interdisciplinary medical careers. A 3D colon model was modelled in ZBrush, and previously validated 3D digital polyp models were embedded within the colon lumen. The colon was segmented so that the model could be 3D printed in parts and connected with embedded magnets, allowing for the model to be broken down into parts to increase educational interactions. The model was 3D printed in thermoplastic polyurethane (TPU) to permit flexibility. It was exhibited at the Museum of Liverpool during the British Science Festival 2025 as an interactive engagement artefact, and facilitated conversations around colorectal anatomy and polyp development, and cancer prevention and screening pathways. Its tactile and visual realism encouraged hands-on exploration and cross-generational engagement. We propose that the use of physical 3D printed colon and polyp models for clinical training can be used as powerful public health communication artefacts.

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3D modelling; 3D printing; colorectal cancer; medical visualisation; public engagement; colonoscopy education

## Introduction

Colorectal cancer (CRC) remains one of the leading causes of cancer-related morbidity and mortality worldwide (Cancer Research UK, n.d.; Kanth & Inadomi, 2021). The majority of CRC develops from adenomatous or serrated polyps, making early detection and removal central to prevention strategies (Leslie et al., 2002). Colonoscopy screening programmes depend upon accurate visual recognition of subtle morphological features that distinguish benign from high-risk lesions.

In our recent publication (Roberts et al., 2024), we described the development and evaluation of high-fidelity digital three-dimensional (3D) models of colorectal polyps designed to enhance endoscopic training. The digital 3D models were presented as interactive online learning resources on Sketchfab (<https://sketchfab.com/PolypProject>) and were positioned as a complementary resource to support colonoscopists' learning. Expert colonoscopists provided feedback on the models and noted that the 3D assets demonstrated educational potential in conveying morphological nuance particularly for surface topology, elevation and spatial orientation: elements that are difficult to fully appreciate in two-dimensional

imagery (Zhou et al., 2021). The models were not designed to replace clinical polyp assessment training but augment the acquisition of diagnostic skills and allow trainees to practice clinical decision-making in a safe, low-stress environment.

Recognising the educational and communicative power of tangible, tactile anatomical models in surgical training (Malik et al., 2015; McMenamin et al., 2014; Preece et al., 2013; Rengier et al., 2010; Wake et al., 2017), we sought to translate the digital 3D polyps into 3D printed models. Physical models allow learners to engage with anatomical structures through spatial exploration and touch, supporting the understanding of complex morphology in ways that two-dimensional images cannot fully convey. Several of the polyps (see Figure 1) were 3D printed using the FormLabs Form 4BL printer with white V4 resin. Such tactile representations have been shown to enhance spatial reasoning, improve learner engagement, and support discussions between clinicians, educators and patients (Fredieu et al., 2015; Lim et al., 2016).

Concurrently, a proposal submitted by author Rankin to host a public engagement event at the British Science Festival 2025 in Liverpool was accepted (British Science Association, 2025). This

**CONTACT** Anna Roberts  [Issarob1@ljmu.ac.uk](mailto:Issarob1@ljmu.ac.uk)  Liverpool John Moores University, Liverpool, UK.

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**Figure 1.** 3D printed polyp models printed in resin reflecting clinically relevant morphologies encountered in screening practice, including pedunculated and sessile lesions, with attention to realistic surface patterning and morphological accuracy.

provided an opportunity to translate the research outputs into a public-facing artefact. We therefore developed a flexible 3D-printed colon incorporating embedded polyp models derived from our original research dataset for exhibition and hands-on interaction with festival visitors. Medical illustration and biomedical visualisation played a central role in translating complex, scientific concepts into accessible visual formats for diverse audiences (Erolin, 2020). Tangible anatomical models can function as powerful communication tools beyond clinical training environments, enabling complex biomedical concepts to be made visible and accessible to wider publics (Erolin, 2019; Lim et al., 2016; McMenamin et al., 2014).

Public engagement with science plays an increasingly important role in improving health literacy and encouraging informed participation in preventative healthcare practices (Jensen & Holliman, 2016). Interactive artefacts and hands-on exhibits have been shown to stimulate curiosity, promote dialogue and enable audiences to explore complex medical concepts in accessible ways (Illingworth & Allen, 2016; National Coordinating Centre for Public Engagement, 2017). Public engagement activities can also foster meaningful experiences through narrative and dialogue, shaping how individuals relate scientific knowledge to their own identities and everyday lives (Davies et al., 2019). For conditions such as colorectal cancer where early detection and screening behaviour significantly influence outcomes (Kanth & Inadomi, 2021), engagement activities that encourage conversation and understanding may contribute to greater awareness of screening programmes and prevention strategies. Rather than functioning solely

as a simulation device, the 3D printed colon model was conceived as an alternative public health communication artefact raising awareness of colorectal cancer, screening, and interdisciplinary medical careers.

## Materials and methods

A 3D colon was digitally modelled by author Roberts by starting from a base cylindrical mesh and using the 'ClayBuildup', 'DAM Standard', 'Smooth' and 'Inflate' tools in ZBrush to sculpt the morphology (see Figure 2). To anatomically approximate luminal diameter and wall thickness encountered in vivo, a shell was created with the desired thickness. Anatomical accuracy was checked by author O'Toole who is a Gastroenterology Consultant for the NHS and expert colonoscopy trainer for the Mersey School of Endoscopy.

The previously validated 3D digital models described in our original study (Roberts et al., 2024) were constructed to reflect clinically relevant morphologies encountered in screening practice, including pedunculated and sessile lesions, with attention to realistic surface patterning and morphological accuracy, and six digital polyp models were embedded within the colon lumen. The colon was designed to be 3D printed in parts and connected with embedded magnets, allowing the model to be separated into sections during demonstrations. This design would enable facilitators to reveal the internal structures and embedded polyps while encouraging interactive exploration by visitors.

The model was exported as a STL file and imported into Bambu Studio to prepare the model for 3D printing. The mesh was segmented by using the 'cut' tool, and the 'add connectors' with type: 'dowl' that was added to set dowl dimensions. The dowls were then removed to leave holes within the model for magnets to be inserted. This process was repeated for each cut, by manually rotating the model to find the optimal orientation, to ensure there was enough thickness for the embedded magnets with no 'floating sections' that wouldn't be attached to the main body. The model was subsequently aligned on the print bed to ensure optimal orientation for printing with supports to reinforce the integrity of the print.

The model was printed by Senior Technician Kevin Erkins using the Bambu Lab H2D printer using thermoplastic polyurethane (TPU), selected for its flexibility and durability with PLA supports. Unlike rigid PLA prints, TPU allows bending and compression, producing a more lifelike tactile response. Flexible materials are increasingly used in anatomical modelling where tactile realism and durability are desirable, particularly in educational or simulation contexts (Lim et al., 2016; Wake et al., 2017).



**Figure 2.** Digital 3D model of a human colon sculpted in ZBrush.

The level of detail and realism within anatomical models can influence how effectively users interpret morphological features and engage with anatomical visualisations (Erolin, 2025). In this model, morphological fidelity was prioritised over photo-realistic colour representation. The colon and embedded polyps were printed in two contrasting colours to indicate segmentation points and to support disassembly during demonstrations. Although the colour scheme does not replicate the appearance of *in vivo* tissue, the sculpted surface topology and morphology of the polyps were preserved to maintain clinically relevant anatomical form. Simplified colour schemes are commonly used in anatomical visualisation to emphasise structural relationships and improve interpretability while retaining essential anatomical information (Strong & Erolin, 2013).

Post-processing included finishing the print by removing any PLA supports using specialised tools to remove each structure, then a simple super glue adhesive was applied to the dowl-shaped holes for the magnets to sit within. The model was mounted onto a bespoke laser cut acrylic stand for safe public handling. See Figures 3–5 for images of the final 3D printed colon model.

The 3D printed colon model was displayed during a public engagement event titled ‘Scope It Out’ during the British Science Festival 2025 at the Museum of Liverpool on the 14<sup>th</sup> of September 2025 (British Science Association, 2025). Overall, this was designed to be an engaging, participatory event demonstrating the wide applications of endoscopic technology across multiple scientific fields; in



**Figure 3.** Flexible 3D-printed colon printed in thermoplastic polyurethane (TPU).



**Figure 4.** Flexible 3D-printed colon printed in thermoplastic polyurethane (TPU) showing a segment removed to reveal embedded 3D polyps and to demonstrate the magnets embedded along the edges of the colon model to enable the model to be taken apart and reassembled.

particular the impact of endoscopy procedures on public health outcomes. The 3D printed colon model functioned as an educational prop and festival visitors were invited to handle the model, identify lesions, scope out the colonic environment using an Depstech DS650 Endoscope and discuss screening pathways with the public (see Figure 6). Interpretive materials accompanied the display, including historical artefacts of endoscopes throughout history, an interactive stomach simulator, and technical activities

related to scope handling with clinicians and researchers on hand to guide and describe the procedures (see [Figures 7 and 8](#)).

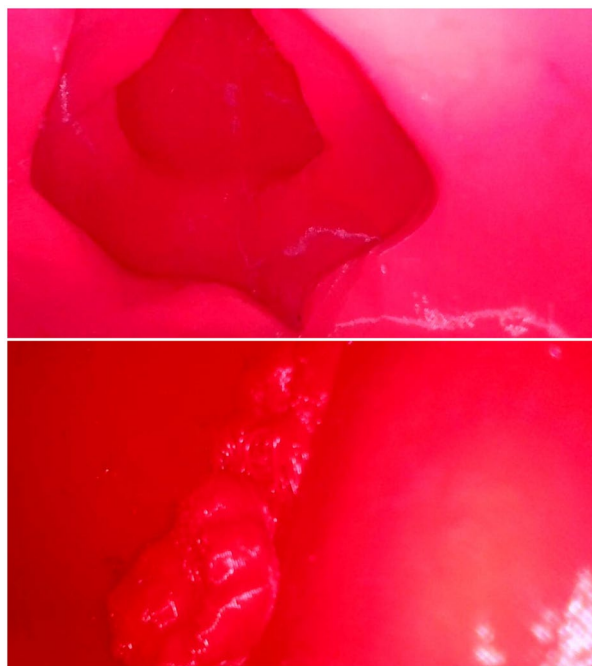


**Figure 5.** Views through a scope inserted in the 3D printed colon model, demonstrating internal surface topology and morphological variation of embedded polyps.

## Discussion

Three-dimensional medical models traditionally exist within training laboratories and simulation suites. By situating our 3D printed colon model within a public museum environment, its function shifted from a specialist training aid to a public engagement artefact designed to stimulate conversation about colorectal health. Museum-based exhibitions and tangible artefacts have long been recognised as effective mediators between scientific knowledge and public understanding, encouraging dialogue, curiosity and informal learning among diverse audiences (Davies et al., 2009; National Research Council, 2009; Simon, 2010). Visitors were not passive observers as they were able to explore the model manually via touch or using a scope to trace folds, locate polyps and visually compare lesion shapes. The experience rendered invisible pathology visible and touchable.

For many participants, this was their first concrete understanding of how polyps develop and why screening matters. Importantly, the model enabled layered conversations about prevention, demonstrating how polyp removal interrupts cancer progression; screening awareness, clarifying why asymptomatic individuals are invited for bowel



**Figure 6.** Public engagement during British Science Festival 2025 at Museum of Liverpool, where visitors explored the tactile model. Image credit: Gareth Jones – British Science Festival 2025.



**Figure 7.** Public engagement during British Science Festival 2025 at the Museum of Liverpool, where visitors explored an endoscopy training stomach using a gastroscope. Image credit: Gareth Jones – British Science Festival 2025.



**Figure 8.** Meet some of the team present during the British Science Festival 2025 at the Museum of Liverpool. Featuring from the left: Susan Baker, Janine Carey, Prof Paul Collins, Melissa Rankin, Anna Roberts and Dr. Adrian McGrath – British Science Festival 2025.

screening; and career inspiration, highlighting the intersection of medicine, technology and art.

Overall, the Festival was attended by 17,441 people over 5 days (British Science Association, 2026). This event was a free, drop in workshop and therefore exact numbers of attendees was not recorded, however the authors' arranged a small survey which captured qualitative feedback from the event participants – this included comments such as 'Fantastic; interactive and informative' and 'A lovely engaging experience about science', highlighting the high level of interest and engagement between the public and LJMU collaborative research team. The public also showed particular curiosity regarding the technological process behind the model's creation. This aligns with studies suggesting that tangible artefacts enhance engagement and retention in science communication contexts. This project illustrates how outputs from peer-reviewed educational research can be repurposed as alternative public engagement and public health tools. By translating polypectomy training tools into an engagement artefact, we broadened the communicative reach of the initial research; the same morphological fidelity valued by endoscopists surveyed in our original research study showed to be equally powerful in demystifying CRC for the public.

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## Author contributions

Credit: **Anna Roberts:** Methodology, Visualization, Writing – review & editing; **Mark Roughley:** Conceptualization, Funding acquisition, Project administration, Resources, Writing – original draft, Writing – review & editing; **Melissa Rankin:** Conceptualization, Data curation, Formal analysis, Project administration, Resources, Validation, Writing – review & editing; **Paul O'Toole:** Conceptualization, Investigation, Resources, Supervision, Writing – review & editing; **Susan Baker:** Project administration, Resources, Supervision, Writing – review & editing.

## Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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## ORCID

Anna Roberts  <http://orcid.org/0009-0008-1628-9730>  
Mark Roughley  <http://orcid.org/0000-0002-7483-859X>  
Melissa Rankin  <http://orcid.org/0000-0002-5905-4965>  
Paul O'Toole  <http://orcid.org/0009-0000-1686-854X>  
Susan Baker  <http://orcid.org/0009-0000-2560-1935>

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