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COMMENT

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A preliminary analysis of the effectiveness of online practical laboratory delivery using 3D models for higher education courses in biological anthropology

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Abstract

Practical-based laboratory instruction represents a substantial component of education in biological anthropology, a multidisciplinary field concerned with investigating human evolution, biology, and behaviour from an evolutionary perspective. The efficacy of online practical laboratory classes using 3D models as part of the mode of delivery, as compared to traditional face-to-face learning, is poorly understood in the field of biological anthropology despite an increased uptake of online learning and the potential benefits of embracing this delivery modality. We present the preliminary findings of an ongoing study exploring the effectiveness of online practical training using 3D resources in biological anthropology. Through a participant survey of undergraduate and postgraduate osteology and palaeoanthropology students (n = 27) from an Australian university, we assess (1) whether differences in teaching modality impact student comprehension of practical concepts and (2) whether student perceptions of learning vary between in-person and online teaching modalities. Our results show that there are no significant differences in test of knowledge scores between online and in-person in either biological anthropology sub-discipline. However, in-person students experienced an increased feeling of learning relative to the online students in our combined discipline and osteology-only cohorts. Feeling of learning scores were statistically significantly lower among the online osteology cohort relative to palaeoanthropology students. Our preliminary results suggest that online labs using 3D models may be an effective means of teaching practical skills in biological anthropology, although student perceptions of learning may be negatively impacted. Feelings of learning are also variable across sub-disciplines, suggesting a need for more nuanced investigations into the efficacy of online learning. Larger sample sizes are required to confirm these findings.

Keywords Human osteology, Palaeoanthropology, Practical training, Online learning, Higher education

Background

Biological anthropology is a multidisciplinary field concerned with investigating human evolution, biology, and behaviour from an evolutionary perspective (Larsen, 2010; Little and Sussman, 2010; Shook et al. 2019). Professional practice in the anthropological subdisciplines of palaeoanthropology and human osteology, which form the focus of this paper, traditionally involves field- or lab-based collection of empirical evidence, through which scientific hypotheses are tested (Bayle et al. 2022; Shook

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et al. 2019; Spiros et al. 2022). Aspiring practitioners in these disciplines therefore require specialist training to develop the key practical skills necessary for leading and participating in field or lab-based research (Bonello 2001; Brookes 2008; Cobb and Croucher 2012; Craik and Collings 2022; Kent et al. 1997).

Online learning is becoming increasingly common in many practice-based fields in both STEM and the humanities, including biological anthropology and its cognate disciplines anatomy, archaeology, biology, and forensic anthropology (Bayle et al. 2022; Derudas and Berggren 2021; Erolin and Rea 2019; Yammine and Violato 2015). Since its inception in the 1970s, there has been intense discussion around the general utility of online education, with its greater flexibility, accessibility, and inclusiveness cited as key benefits (Mitchell and Delgado 2014; Lloyd et al. 2012; Dumford and Miller 2018; Bernard 2021; Almahasees et al. 2021). Within STEM disciplines, however, online learning has traditionally been perceived to be an unsuitable medium for the delivery of practical training (Peuramaki-Brown et al. 2020), prompting educators to turn to the use of digital 3D materials to replicate in-person learning experiences (e.g., Gutiérrez-Carreón et al. 2020; Hilbelink 2009; Prabhakaran et al. 2018). In anatomy, biology, and archaeology, these materials have included digital 3D surface models, medical computed tomography (CT) models, 3D visualisation systems, and virtual reality environments (Bayle et al. 2022; Derudas and Berggren 2021; Erolin and Rea 2019; Peuramaki-Brown et al. 2020; Petersson et al. 2009). Although the use of 3D models has been shown to improve both student engagement and factual and spatial knowledge acquisition, not all in-person experiences can be replicated, leading some researchers to conclude that 3D technologies are best used to 'enhance' in-person learning (Erolin and Rea 2019; Yammine and Violato 2015). There has been little specific research investigating the utility of 3D models in a pedagogical context in biological anthropology (though see Craik and Collings 2022 and Shulz 2022 for exceptions).

Here, we present the preliminary findings of an ongoing study exploring the effectiveness of online practical training using 3D models in biological anthropology. We aim to understand whether online practical laboratory sessions using 3D models are an effective alternative to traditional, in-person practical training. Through a participant survey of osteology and palaeoanthropology students (n = 27) from an Australian university, we assess (1) whether differences in teaching modality impact student comprehension of practical concepts and (2) whether student perceptions of learning vary between in-person and online teaching modalities.

Methods

Students who were aged 18 or over and enrolled in introductory osteology and palaeoanthropology courses at the Australian National University (Additional file 1) were eligible to participate this study. We assessed student perceptions of learning and knowledge comprehension in relation to one lab from each course (Additional file 2). To ensure equal participation across the online and in-person study conditions, half of the students from each course were assigned to participate in the lab online and half in-person. Detailed information on lab delivery can be found in Additional file 2.

Following the labs, participants were invited to complete a two-part online survey via the Qualtrics web platform (Additional file 3). In Part One, participants were asked to answer five Likert Scale questions gauging their 'Feelings of Learning' (FOL) (Deslauriers et al. 2019). The inter-item consistency of Part One was analysed using Cronbach's alpha, with results indicating high reliability (Cronbach's alpha = 0.9542, Nunnally 1978). Part Two involved a 'Test of Knowledge' (TOK) assessing student comprehension of the lab content. Both online and in-person students completed this test online. All study participants answered the same set of FOL questions, whereas TOK questions were course specific.

Wilcoxon rank-sum exact tests were used to assess whether students experienced significantly different TOK and FOL outcomes between in-person versus online delivery modes (Bland 2015). Analyses were conducted at the combined cohort (both courses online vs. both courses in-person) and individual cohort (osteology

Table 1 Means, standard deviations, and Wilcoxon rank-sum results for Test of Knowledge (TOK) data collected to measure student comprehension of in-person and online biological anthropology laboratory content

In-Person (n = 16)		Online (n = 11)				In-Person (n = 7)		Online (n = 7)		*z*	*p*	In-Person (n = 9)		Online (n = 4)		*z*	*p*
Mean	*SD*	*Mean*	*SD*	*z*	*p*	*Mean*	*SD*	*Mean*	*SD*			*Mean*	*SD*	*Mean*	*SD*		
3.63	0.89	3.09	1.38	1.081	0.281	4.14	0.69	3.57	1.397	0.744	0.573	3.22	0.83	2.25	0.95	1.621	0.143

Tests comprised five subject-specific multichoice questions on content covered in the practical lab. Mean scores out of five were calculated for each cohort, with 5/5 representing excellent comprehension of lab content, while scores of 0/5 represent poor comprehension

Table 2 Means, standard deviations, and Wilcoxon rank-sum results for Feeling of Learning (FOL) data for in-person and online biological anthropology practical sessions

Feeling of Learning Question (after Deslauriers et al. 2019)	Combined cohorts						Osteology						Palaeoanthropology					
	In-person (n = 16)		Online (n = 11)		*z*	*p*	In-person (n = 7)		Online (n = 7)		*z*	*p*	In-person (n = 9)		Online (n = 4)		*z*	*p*
	Mean	SD	Mean	SD			Mean	SD	Mean	SD			Mean	SD	Mean	SD		
I enjoyed this lab	4.50	0.52	3.09	1.38	3.611	< 0.001	4.71	0.49	2.42	1.13	3.338	0.001	4.33	0.50	4.25	0.95	1.281	0.333
I feel as though I learned a great deal from this lab	4.56	0.51	2.64	1.43			4.71	0.49	2.00	1.15			4.44	0.53	3.75	1.25		
The demonstrator was effective at guiding my learning	4.56	0.51	3.64	1.21			4.85	0.38	3.29	1.25			4.33	0.50	4.25	0.95		
I wish that all of my biological anthropology courses were taught this way	4.25	0.77	2.00	1.41			4.71	0.76	1.14	0.38			3.88	0.60	3.50	1.29		
I feel confident that I could demonstrate my understanding of the learning objectives in a test	3.81	0.54	2.64	1.36			4.14	0.38	2.14	1.21			3.55	0.53	3.50	1.29		
The resources provided for this lab deepened my understanding of the concepts presented in today's lab	4.69	0.48	2.82	1.40			5.00	0.00	2.00	1.00			4.44	0.53	4.25	0.50		
Average FOL by Teaching Mode	4.56	0.51	2.82	1.07	-	-	4.86	0.38	2.29	0.76	-	-	4.33	0.50	3.75	0.95		

All FOL questions were assessed using a Likert scale ranging from 5 Strongly Agree to, 1 Strongly Disagree

online vs. osteology in-person; palaeoanthropology online vs. palaeoanthropology in-person) levels using Stata/BE 17.0 for Mac (StataCorp 2023). Ethical permissions for this study were granted by the ANU Human Research Ethics Committee (Protocol 2022/216) and the ANU Planning and Services Performance Team.

Results

A total of 27 students participated in the survey, with the osteology cohort comprising 52% (n = 14) of participants and the palaeoanthropology cohort 48% (n = 13). Detailed information on the participants and survey response rates is provided in Additional file 2.

Test of knowledge

There was no significant difference in TOK scores between the in-person (mean TOK ≥ 3.22, SD ≥ 0.83) and online (mean TOK ≥ 2.25, SD ≥ 0.95) cohorts for the combined, osteology, and palaeoanthropology groups ($z \geq 0.744$, $p \geq 0.143$, Table 1). There were no significant differences between the osteology and palaeoanthropology cohorts when controlling for online or in-person delivery type ($z \geq 1.656$, $p \geq 0.146$, Additional file 4).

Feeling of learning

In-person students in the combined and osteology only cohorts experienced significantly higher feelings of learning (mean FOL ≥ 3.81, SD ≥ 0.00) relative to the online students (mean FOL ≥ 1.14, SD ≥ 0.38, $z \leq 3.338$, $p \leq 0.001$, Table 2). There were no statistically significant differences in feeling of learning between the in-person (mean FOL ≥ 3.55, SD ≥ 0.50) and online palaeoanthropology cohorts (mean FOL ≥ 3.50, SD ≥ 0.50; $z = 1.281$, $p = 0.333$, Table 2). Comparisons between the in-person osteology and palaeoanthropology cohorts show that there were no significant differences in feeling of learning between these groups ($z = 2.029$, $p = 0.109$, Additional file 4). However, feelings of learning were significantly decreased among online osteology students relative to online palaeoanthropology students ($z = -2.383$, $p = 0.024$, Additional file 4).

Discussion

Our preliminary findings suggest that online learning using 3D models does not negatively impact student comprehension of lab concepts, as demonstrated through a test of knowledge. Online lab delivery may therefore represent an effective alternative to in-person laboratory practicals, enabling engagement with broader student cohorts (e.g., distance learners). However, online students experienced significantly decreased feelings of learning compared to in-person students in the combined and osteology-only cohorts. This trend was not observed among palaeoanthropology students. This finding is supported by several investigations demonstrating that decreased feelings of learning are not reflected in student outcomes (Supriya et al. 2021; Cavanaugh and Jacquemin 2015; Chan et al. 2021).

The impacts of variations in teacher experience, delivery mode and style, and student proficiency were minimised through the selection of courses, teachers, and students of similar skill from within one major at the same university. As such, variations in feelings of learning may therefore reflect differences in students' levels of experience with online learning between the cohorts (Additional file 2), as well as variation in course content and types of lab activities, the perceived quality of 3D resources, student engagement and interaction, and differences in student moods, emotions and learning styles (Alshare et al. 2011; Gray and DiLoreto 2016; Parahoo et al. 2016; Salter and Gardner 2016). Although preliminary, our results suggest that the perceived effectiveness of online labs varies across biological anthropology subdisciplines and that more nuanced investigations into the efficacy of online learning are required.

Our preliminary study is limited by its short duration (one lab session), small sample size (n = 27) and low participant response rates (Additional file 2), underscoring that the data presented here may not be representative of the broader student community and should be considered with caution. However, these data provide a valuable resource for assessing the effectiveness of teaching and learning in hands-on fields, and for refining educational best practice in biological anthropology and beyond.

Abbreviations

3D	Three Dimensional
ANU	Australian National University
FOL	Feeling of Learning
STEM	Science, Technology, Engineering and Mathematics
TOK	Test of Knowledge

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12052-023-00190-w.

Additional file 1: General course outlines.

Additional file 2: Participant, teacher, and lab information.

Additional file 3: Survey.

Additional file 4: Results table for osteology vs. palaeoanthropology comparisons.

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Author contributions
S.M.W.: conceptualisation, methodology, investigation, data curation, formal analysis, writing (original draft), project administration, funding acquisition; K.L.B.: conceptualisation, methodology, investigation, writing (review and editing), project administration, funding acquisition; L.A.B.W.: conceptualisation, methodology, writing (review and editing), project administration, funding acquisition, supervision.

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Availability of data and materials
The dataset supporting the conclusions of this article are included within the article and its additional files.

Declarations

Competing interests
The authors declare that they have no competing interests.

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