



# “Learning by Doing”: a Mixed-Methods Study to Identify Why Body Painting Can Be a Powerful Approach for Teaching Surface Anatomy to Health Science Students

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Accepted: 14 August 2021 / Published online: 9 September 2021  
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## Abstract

**Introduction** Teaching human anatomy to produce deeper understandings and knowledge retention in learners requires meaningful, engaging, and practical activities. Previous studies identify that most students who participated in body painting (BP) reported improved understanding of surface anatomy (SA). This study investigates the key factors underpinning *how* BP helps students learn SA.

**Methods** The study involved an explanatory mixed-methods approach. Towards the end of an anatomy course, a survey was administered to three cohorts of first-year chiropractic, osteopathy, and Chinese medicine students and second-year biomedical sciences students over 3 years ( $n = 311$ ; response rate = 30%). The survey assessed the effectiveness of BP as a hands-on, group-based approach for learning SA in practical class. Three student focus groups ( $n = 13$ ) explored the key survey findings.

**Results** Overall, 72% of student respondents reported BP activities helped them learn SA “quite a bit” or “very much”. Multivariate analysis identified students found BP helped them learn SA by “remembering the position of the bones, joints, muscles, actions and insertions” (POR = 5.7;  $P < 0.001$ ); “integrating textbook and other knowledge on a real live person” (POR = 2.4;  $P = 0.027$ ); and “achieving a deeper understanding of SA” (POR = 5.2;  $P < 0.001$ ). The qualitative findings describe specifically how BP helps students learn, understand, and remember SA.

**Conclusions** The findings show the majority of students believed BP benefitted their learning of SA through enhancing engagement in self-directed classroom and out-of-hours learning opportunities, deeper understandings of form and function, retention of knowledge, and practical physical examination experiences palpating the variations in form between individuals.

**Keywords** Gross anatomy education · Undergraduate education · Health profession education · Body painting · Active learning · Engagement · Learning · Innovation · Surface anatomy

## Introduction

Historically, the use of prosections and cadaver dissection have been the focus of anatomy teaching and learning [1–5]. Although engaging, and beneficial for learning of anatomy, the emphasis on cadaver dissection has changed dramatically over the past 20 years due to decreases in cadaver donations and an increase in student numbers [6]. Even though

the use of human prosections is central to and invaluable for learning anatomy, studies propose it is important that students also concentrate their efforts on surface anatomy [7–10]. Surface anatomy is “visual anatomy” — dealing with anatomical structures on living bodies that can be studied only with sight, such as the form and proportions of the body and surface landmarks that relate to deeper structures [11–13]. Surface anatomy allows students the opportunity to consolidate the anatomy that they have learned using the prosections and relate it to living beings. As future health professionals, students must work on live patients or clients, and so must be able to identify anatomical structures on real bodies [14]. Surface anatomy also teaches students physical examination skills: to observe, examine, and interact with a living person [15] that necessarily involves observation, palpation of bony prominences, muscles, and tendons, and

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the identification of surface projections of bones, muscles, or organs on the body surface or walls. The study of surface anatomy is particularly important in studying the musculo-skeletal system, as students can see structures moving and functioning.

More recently, with a reduction in contact hours to teach anatomy [4], there has been a move to complement the use of prosected tissues in the laboratory using multi-disciplinary [16], more pro-active, *non*-didactic, “hands-on” approaches [14, 17]. Stimulating, engaging, experiential [18, 19], and fun learning approaches appear to produce students who are pro-active, confident, and self-directed learners [14, 17]. This experiential learning includes the use of whiteboards as learning tools, and Play Doh for modelling anatomical structures, movements, and surface anatomy that appear to assist students to experience deeper learning [14, 17]. For example, surface anatomy can easily be undertaken on oneself, classmates, colleagues, family, or friends.

Body painting (BP) has been identified as an effective tool for learning surface anatomy and associated clinical skills [15, 17, 20–28]. BP is a fun teaching and learning approach that is popular among students, as it is an engaging way to learn anatomy by looking, identifying surface landmarks, palpating, drawing, and then painting [14, 17, 20]. BP is a motivating and creative experience for students that provides memorable visual images [21] and encourages multisensory and active participation [14, 17]. While BP is suitable for all students, cultural sensitivity and careful negotiation may be necessary to ensure all students are comfortable carrying out the activities. For example, at a regional Australian medical school (James Cook University), students from many cultures, including Muslim students, were enthusiastic about participating in BP activities and through careful negotiation were able to find areas of the body they were all comfortable to paint [14, 17]. Students have also reported that they participate in BP activities in their free time with classmates and friends, further supporting this as an engaging learning approach [14, 17].

### Introducing Body Painting Activities to Anatomy Curricula in Australia

BP has become an accepted teaching approach used by medical and health science courses around the world and in Australia [15, 17, 20–28]. From 2010 to 2021, the first author of the present study has included BP as one of several strategies for teaching anatomy at James Cook University (JCU), Royal Melbourne Institute of Technology (RMIT) University, La Trobe University, and Charles Sturt University (CSU). Before BP was included in the curricula, anatomy at these universities was delivered didactically with more individually oriented learning activities

in the practical class — disadvantaging and disengaging students who prefer hands-on learning and/or group learning activities. Adding BP to anatomy practical classes was undertaken to cater specifically for the learning styles of these types of students [14, 17]. However, BP is not yet a standard component of Australian anatomy curricula, and there are no studies reporting the mechanisms by which BP assists or improves student learning. Thus, this study used quantitative and qualitative investigations to identify and understand *key factors* underpinning *how* BP helps students to learn surface anatomy.

## Materials and Methods

### Practical Classes

The first author’s approach to teaching surface anatomy via BP consisted of multi-sensory, “hands-on” learning modelled by the academic staff and tutors during 2-h weekly practical classes. The laboratory was arranged so students worked in groups around a dissection table, with a whiteboard at one end. Students were required to work together to demonstrate that they had a deeper understanding of the structures and relationships during their study of the prosections. After studying the prosections, students were encouraged to move to a separate section of the laboratory setup for experiential learning of surface anatomy using Play Doh for modelling anatomical structures, movements (learning using hand gestures, weights, or hula hoops for example), and BP. Students were trained in BP techniques from week 1 onwards to encourage participation, with guidelines for BP also included in practical class notes. Focus was placed on the “process” of BP rather than the finished product. Students were encouraged to undertake a systematic approach to BP: physical examination involving observation of bony landmarks, form, and proportions, followed by palpation of important landmarks, then the use of whiteboard markers to outline important landmarks (landmarking), then drawing in the origins and insertions, then outlining the important organs, and finally, undertaking the painting itself. Students were encouraged to use different colors and shading to indicate muscles, tendons, and bones.

The first author also ran an annual “Anatomy Cup” competition that encouraged the use of innovative approaches to learn anatomy. This inter-cohort competition consisted of a series of activities including whiteboarding, Play Doh construction, bone identification, and BP. Students spent the semester preparing for this competition and it was a great incentive and driving force to their participation in surface anatomy and BP.

## Study Design and Participants

This study utilized an explanatory mixed-methods design. The development of the BP activities has been ongoing at four Australian Universities over 11 years. The data used in this study was collected at RMIT University from three successive cohorts of health science students, involving first-year chiropractic, osteopathy, and Chinese medicine students, and second-year biomedical science students. The self-administered survey on student perceptions of the BP approach was delivered after the final anatomy lecture. The researchers explained the study as the surveys were administered to the students via online information sheets and in person. Analysis of the survey data allowed the major factors to be identified for how BP helps students to learn surface anatomy, and these key factors were later investigated in the qualitative component involving three focus groups — one each for students from biomedical science, Chinese medicine, and chiropractic and osteopathy disciplines. The qualitative component utilized a basic descriptive design [29] to produce simple context-sensitive summaries of students' experiences with BP. This approach allowed in-depth exploration of how BP activities helped student participants learn surface anatomy. This research was approved by the RMIT Human Ethics Committee (ASEHAPP 16–13). In addition, students were asked to sign a media release form in week 1 to allow researchers to use photographs.

## Survey

The survey collected data on demographics (age, gender) and variables known to predict student engagement in BP, such as enjoyment, quality of learning experiences, relevance to future student years and career, active involvement in BP activities, class bonding, and overall level of interaction with teachers/tutors [30–32], with students rating each variable across a scale of 1 to 10 (with 1 being the lowest and 10 being the highest). Students were also asked to rate, across a 4-category Likert scale (“not at all”, “a little bit”, “quite a bit”, “very much”), how much BP helped them learn anatomy, assist their long-term memory of human anatomy, assist their deeper understanding of human anatomy, identify the position of bones, muscles and their origins, learn the muscles and other structural anatomy, inspired/motivated them to learn anatomy, etc. The surveys were administered in the final week of lectures to allow students to more accurately self-assess how well the BP activities had assisted their recall and learning of anatomy, both week-to-week over the semester and in the lead up to studying for their final exams. A full list of the variables as they appeared in the survey is provided in Table 1.

## Focus Groups

Three separate focus groups were held with RMIT University students of Chinese medicine (1 male, 1 female), biomedical science (1 male, 3 females), and chiropractic and osteopathy (4 males, 3 females). Discussions were conducted by the co-author TW (JCU medical school academic having no role with the RMIT program). All participants were considered to be information-rich cases that allowed the research questions to be adequately explored [33].

## Data Analysis

Survey data were coded numerically and entered into SPSS release 19 for Windows. Table 1 describes numerical variables as mean values and standard deviations, while categorical variables are described as frequencies. Binary logistic regression analysis (Table 2) identified independent predictors of why RMIT health science students believed BP helped them to learn anatomy “quite a bit”/ “very much”, and estimated their strength of association. All engagement variables listed in Table 1 were considered in the multivariate logistic regression analysis, but only independent significant predictors were accepted into the final model. Results of the multivariate logistic regression analysis are presented as prevalence odds ratios (POR) together with 95% confidence intervals (95%-CI). POR gives an estimation of relative risk with fewer assumptions than are required for prevalence ratio analyses, and are the generally accepted measure of association used in cross-sectional studies to assess the strength of the relationship between study factor and outcome [34]. Throughout the study, a statistical test was considered significant when  $P < 0.05$ .

Analysis of the qualitative interview data involved digitally recording the discussions and then transcribing a summary of the conversation into a Microsoft Word document. Electronic summaries of the interview were read repeatedly to develop a high level of familiarity with the data (immersion), and then summarized by manually coding into recurrent themes. This thematic analysis was conducted by the author TW, and later checked by CD for investigator triangulation; differences were resolved through discussion between the authors. The sample size in the study was sufficient to allow a “theory-saturation point” to be reached, where new discussions no longer produced new information [33]. Quotes that captured the concepts held by a number of participants were included (Tables 3 and 4).

## Results

Participation in BP activities in the laboratory was always optional and never obligatory, though most students participated willingly (Fig. 1). The first author taught the BP

**Table 1** Self-reported engagement and learning of 311 Royal Melbourne Institute of Technology health science students from participating in body painting (BP) activities associated with surface anat-

omy. Students rated each variable across a scale of 1 to 10 (with 1 being the lowest and 10 being the highest)

Body painting variables	Frequency for categorical variables or mean and standard deviation for numerical variables
I prefer 'hands-on' learning activities or 'no preference' over learning from 'didactic teaching' (rating from 1 to 7, with 4 being 'no preference')	79%
I prefer 'group-based' learning activities or 'no preference' over learning from 'individual-based' learning activities (rating from 1 to 7, with 4 being 'no preference')	70%
Enjoyment from participating in BP learning activities (rating from 1–10)	7.1 ± 2.3
Quality of learning experiences from BP learning activities (from 1–10)	7.0 ± 2.2
Relevance of BP to later years of course and future career (from 1–10)	6.8 ± 2.2
Level of active involvement in BP learning activities (from 1–10)	6.2 ± 2.6
Sense of accomplishment from completing BP learning activities (from 1–10)	6.9 ± 2.1
Level of interaction and discussion with peers and staff during BP activities (from 1–10)	7.8 ± 1.9
BP activities helped in bonding the class closer together 'quite a bit/very much'	69%
BP activities were enjoyable 'quite a bit/very much'	77%
BP inspired /motivated me to learn Anatomy 'quite a bit/very much'	68%
BP helped me to learn Anatomy 'quite a bit/very much'	72%
BP helped me to integrate textbook and other knowledge on a real live person 'quite a bit/very much'	77%
BP assisted my deeper understanding of Anatomy 'quite a bit/very much'	75%
BP assisted my long-term memory of Anatomy 'quite a bit/very much'	75%
BP helped me to identify the position of bones, joints, muscles and their origins 'quite a bit/very much'	76%
BP helped me to remember the position of bones, joints, muscles, actions and insertions" 'quite a bit/very much'	76%
BP activities made it easier to learn muscles and other structural Anatomy than from textbooks 'quite a bit/very much'	69%

process in a way that encouraged students to participate without requiring advanced artistic abilities (Fig. 1). Most anatomy learning occurred during the landmarking phase of the BP process (Fig. 1A, B), which was then followed by the BP using paints and paintbrushes (Fig. 1C–E). Students from different cultural backgrounds were also keen to participate, and their involvement was achieved by negotiating which parts of the body were acceptable for painting (Fig. 1E). BP was an approach able to be used by any student to learn anatomy, with students consolidating what they learn with prosections by looking at the surface anatomy relevant to the area on themselves and each other, and often after class on family and friends.

Students worked in groups for BP, and the activities promoted peer interactions and class bonding (Fig. 2A, C). Students alternated their roles as models, artists, or general helpers (holding atlas pictures, providing paints and supplies). As the final step, the BP work carried out by health and biomedical science students in years 1 and 2 was photographed and uploaded weekly onto a Facebook

page called "Innovative Anatomy" (<https://www.facebook.com/Innovative-Anatomy-179607045387194>). This page allowed the work done by students in practical classes to be shared and used by all students for their study. BP was a popular approach to learning anatomy not only with university students, but also by professionals in the health and funeral industries. The Innovative Anatomy Facebook page has followers all over the world, and media coverage of the body painting resulted in this work being presented to external groups such as radiographers and other specialists from the local hospital (Fig. 2B), and to conferences of the British Institute of Embalmers, and the Australian Institute of Embalmer's from 2012 to 2019 (Fig. 2D, E).

Three hundred and eleven (311) health science students across years 1 and 2 responded to the end of year surveys over 3 years (overall response rate = 30%): cohort 1  $n = 95/364$ ; cohort 2  $n = 106/352$ ; and cohort 3  $n = 110/354$ . Health science students had a mean age of 21 years ( $\pm 5$ ), with 188 (61%) being female. Overall, 72% of health science students reported BP activities helped them learn surface

**Table 2** Results of multivariate logistic regression analysis identifying the factors which predict Royal Melbourne Institute of Technology health science students ( $n = 303$ ) believing body painting (BP) helped them “quite a bit”/ “very much” to learn anatomy

Predictors	Sample ( $n = 303^{\#}$ )	BP helped me to learn anatomy (218, 72%)	POR [95%-C.I.]	P-value
<b>BP helps to integrate textbook and other knowledge onto a real live person</b>	69	24 (35%)	1	0.027
<i>Not at all/ Only a little</i>	234	194 (83%)	2.4 [1.1 – 5.2]	
<i>Quite a bit/ Very much</i>				
<b>BP assists deeper understanding of anatomy</b>	76	23 (30%)	1	<0.001
<i>Not at all/ Only a little</i>	227	195 (86%)	5.2 [2.5 – 10.9]	
<i>Quite a bit/ Very much</i>				
<b>BP helps to learn and remember the position of the bones, joints, muscles, and insertions</b>	72	21 (29%)	1	<0.001
<i>Not at all/ Only a little</i>	231	197 (85%)	5.7 [2.8 – 11.7]	
<i>Quite a bit/ Very much</i>				

POR [95%-C.I.] prevalence odds ratio [95%-confidence interval]

<sup>#</sup>Only data of health science students with no missing values for all predictors accepted into the model were analyzed (8 students had missing data from the total of 311 students)

anatomy “quite a bit” or “very much”. The multivariate analysis identified the independent predictors for why students thought BP was a significant help for them in learning anatomy: “helped me to remember the position of the bones, joints, muscles, actions and insertions” (POR = 5.7;

$P < 0.001$ ); “helped me to integrate textbook and other knowledge on a real live person” (POR = 2.4;  $P = 0.027$ ); “assists your deeper understanding of Anatomy” (POR = 5.2;  $P < 0.001$ ) (Table 2).

**Table 3** Summary of themes and comments made in three focus groups of Royal Melbourne Institute of Technology health science students ( $n = 13$ ) about the benefits of body painting activities in

motivating them to learn, better understand, and remember clinically relevant surface anatomy

Learning strategy	Why this learning strategy works	Learning outcomes for students
Group-based, self-directed learning approach supported by tutors and the lecturer	<p><b>More focused, collegial and engaging interactions with tutors and lecturers</b></p> <p>Better communication—you’re asking more questions to tutors, lecturers or fellow students. And not only are you communicating but you’re working towards something (male Osteopathy student)</p> <p>Some people may be a bit intimidated by it, having to go up and ask a tutor for help but when you’re BP you look at where it goes and it’s not as intimidating. It’s a more friendly open line of communication (female Chiropractic student)</p> <p>I think it [BP] did create a real fun element in the room though, there was a lot of laughing and a lot of encouragement, especially when we got towards the middle of the semester and the next half people were saying, come on, it’s your turn to be BPed, come on have a go, it had really developed a big comradery sort of feel (female Chiropractic student)</p> <p><b>Students ‘learn how to learn’</b></p> <p>Self-directed study I think really helps for first and second year students. I’ve learned ways now, methods to learn (male Biomedicine student)</p> <p>It’s really self-directed learning. It’s not them holding your hand telling you to do this and this and this. She’ll literally sit in there and she’ll talk to you, she’ll help you but it’s all on you. You can sit there and do nothing the whole practical. If you want, you could go—no skin off her bones if you do go (female Biomedicine student)</p>	<p><b>Learning with other students and tutors helps to identify and confirm the correct anatomy knowledge</b></p> <p>It’s also very good for both sides, not only the person getting painted but also the person painting. To paint the other person they need to know this muscle is over here, there, there, there, so supplementary knowledge. And the one getting painted, “oh, so that’s where it is, I thought it was actually there”. There’s more interaction, it’s better than just sitting around (male Osteopathy student)</p> <p>It helps you learn how to work together as a group. One thing I really learned, its hard sitting on your own, you don’t have anybody to go “hey is one plus one really one? Two. You know it’s like double checking and you know you are not just learning for you, you’re learning for both of you. You’re making sure that both of you, or however many are in the group understand. I remember I worked with a guy and it was on the nerves of the arm, and I was having a really hard time of it and I was sitting there asking him the same question over and over again. What does this mean? What is the BCC? It was nice having other people around, I wasn’t the only one that didn’t understand it. You know having someone else talk it through with you, physically show you it, it really helped. I’m always basically hey do you want to study with me now. We’re probably going to be here all day looking at the stuff, body painting. It helps you learn, how to learn with other people (female Biomedicine student)</p> <p><b>Students more strongly engage with Anatomy course content/ more motivated to learn</b></p> <p>With these [BP] labs, it’s such a different environment to our other labs, like Biochem that’s so structured, you don’t have any freedom to do what you want. You feel a lot more motivated coming out of the lab to go home and do your own personal study. I find that I write a lot less, but it has a lot more meaning and it’s better set out and a lot more images than the writing (female Osteopathy student)</p> <p>In my spare time, I touch and think about the muscles more (male Biomedicine student)</p>

Table 3 (continued)

Learning strategy	Why this learning strategy works	Learning outcomes for students
Students practically apply textbook and other didactic knowledge on a real live person by taking time to identify the muscles, tendons, blood vessels and other SA through palpating, moving and other practical classroom aids, and then using colour paints to differentiate the various anatomy	<p><b><i>Students practice on ‘real live people’ with palpating and flexing muscles</i></b></p> <p>If you want to have a cadaver you know where they are but in real life we’re dealing with a living person. By doing BP you have to palpate and see which muscle, and where does it link to. Some people found it hard to palpate because some people have thicker skin so I think it’s important not only for us to learn but for us to practice palpation (male Chiropractic student)</p> <p>The thing that helped a lot was with a real-life person. In anatomy we look a lot at cut up specimens and all that. But with real life people you can actually feel the muscles, the bumps, you know which ones are which, it helps a lot to distinguish which ones are which and it helps a lot with movements. So if you paint the arms you can see which are involved in flexion. I found it very helpful (male Osteopathy student)</p> <p>When you read out of the textbook in a didactic manner, at the end of the day, you’re not in real terms because you’re in 2 dimensions, you’re looking at a page. When you are BPing, like when you’re looking at a specimen, you are looking at it in real terms, in 3 dimensions. A muscle in a book looks very different to a muscle in real life. Just because of that added dimension, that added complexity. That’s why I think it’s useful as well, because a lot of people body paint by first looking at the textbook and looking at where the muscles are supposed to be and in that way they can apply it, in 3D terms and I think that’s another way in which you help to remember the information, to know where all the muscles are, the bones, and that’s why I think it’s really useful as well (male Chiropractic student)</p> <p>In the textbook everything is so neat and set out and separated and then you get in there and it’s what the hell is that? When you do the BP you have to feel it, you have to palpate, all that kind of stuff and it really does cement that kind of learning. If you go to a prosection or a textbook you think that doesn’t look like that at all. When you feel it on a person you go yeah I can kind of feel how that fits in there (female Chiropractic student)</p> <p>[Palpating] is part of the learning experience with BP. to me BP is not just ok we’re going to put some paint on your arm and we’re going to outline some muscles, you need to palpate. So you know what muscles you’re working with, you know where they are. Where they originate, where they insert, and from there you apply paint and you do the textures and depending on, regardless of skill or regardless of artist technique it’s a massive learning experience. You’re not just doing one process, you’re palpating, then you’re painting making sure you get everything right. That’s why it’s useful, it’s not just one process to learn, it’s a combination of processes. So I think anyone who does BP is at an advantage to anyone who doesn’t do it (male Osteopathy student)</p> <p><b><i>Students can use colour to differentiate the details of surface anatomy</i></b></p> <p>Most of the prosections in the lab they are very old. And they have lost the natural colour of the muscles and you cannot in the first view distinguish between the muscle and the tendon, or even the layer, sometimes the direction of the muscle fibres it’s destroyed during several years using them. But when you do this body painting, because you want to make a contrast, you want to make a difference between underneath and the top, or the medial one, you need to do work with the colour. For me keeping in the memory. Now I can show you my papers, if I want to learn the cutaneous branches of the nervous system to the lower limb or the upper limb, I’m using the colour on the paper. So I believe colour is a miracle, it helps you to learn everything (female Biomedicine student)</p> <p>When I’m painting by colour, I sho (female Biomedicine student) the different structures, tendon, muscles. I do believe this painting in my opinion mixed with looking at the prosections, in picture or alive in the lab together it’s very strong – very helpful to understand the concepts of anatomy. In terms of learning, I think it works really well. If you’re getting painted, pointing and naming all muscles as you are doing it, helps you learn. Anything practical is gonna always work very well (female Biomedicine student)</p> <p>[Lecturer] is really, really, good at it. So something that someone did in one solid colour she’d look and say well you can tell the tendons here and she’d make the colour different there. Now I know that this is definitely a tendon because she painted it on there as a tendon rather than one solid colour. I like the more detail, which you have to like art to do. The more detail you put into it, the more you understood it. The more time you spend on something, the more it sticks in your brain (female Biomedicine student)</p> <p>It makes a huge difference, oh my God, me and anatomy we don’t usually get on at all and now I’m like yeah, I could probably name a couple of muscles. Before I would have been the person to say I don’t remember any of that (female Biomedicine student)</p>	<p><b><i>Retaining a stronger memory of the position of muscles, bones, joints, actions and insertions and a deeper understanding of Anatomy</i></b></p> <p>I found even my test results varied a lot, a couple of weeks I didn’t do BP and we had a spot test on it and I did a lot worse. I was getting higher marks. I found that for long-term memory it really did help. Especially if you’re a hands-on learner, I’m not the kind of person that can sit down and look at a book because I’ll go to sleep – it’s boring. I need to get in there and feel around, actually be actively doing something (female Chiropractic student)</p> <p>The BP did help a lot with the remembering things so that you weren’t just rote learning them. You had to sit down and go through and remember and it was pretty fun. Anatomy can be quite dry at times and it was a really engaging way of learning (female Osteopathy student)</p> <p>I remember in the beginning of the semester I looked at the subject and found the textbook. I was terrified. Oh my God, so much names, I can’t keep in my mind. Good for the young people. I was a little bit shocked. In the beginning when I came in the class Claudia explained “don’t worry guys, we’ll teach you how to make this easy in your mind.” I wasn’t sure about the BP but when I attended the first time, it’s easy to keep in your mind exactly the look of the muscles and bones and remembering all the time. It jogs your memory in your mind when you are body painting and it’s very helpful to learn. Not just memorizing and after exam you will forget it. It’s long term and in my opinion now I can say I have more confidence about anatomy and for the future I think (female Biomedicine student)</p> <p><b><i>Career benefits from wider practice with palpating the different sized and shaped muscles of different people</i></b></p> <p>You need that exposure, when we finish this course, we need to know what someone who has more muscular muscles, how the muscles are, their range, how far they extend. It’s good that we even get to have that practice, even doing the palpating with the PB. Otherwise if we don’t get that practice, when we’re in the real world we’re going to freak out, keep seeking advice from our mentors or keep referring to textbooks rather than relying on our own experience (male Chiropractic student)</p> <p>And you learn how to palpate, how to touch. Learn and find for example where this muscle is sitting, palpate it, like a future patient for you. It’s very good when you know what the movement is for example, abduction, adduction, supination, pronation. You have some idea about some muscles, but when you palpate it, you feel it. This muscle is doing this, and this muscle is doing that (female Biomedicine student)</p> <p><b><i>Recognizing the value of including different learning approaches (visual summaries, etc.) into university study and future life-long learning</i></b></p> <p>I think it’s still a really good way cause it’s helping my study, cause the way I used to study might seem quite didactic, I made sure that I sit down and I write for approx 2 h or whatever. But now, I’m drawing and labelling things because that’s one of the things that really helped me with anatomy cause my anatomy not book, half of it is just page long images. Not only am I proud of the work that I’m doing but it’s so much easier too. I remember where everything is, and what I have to know and what order it’s in. And I can throw that into my other subjects that I’m doing and it only compliments my learning ability. I’ve definitely taken something away, not only from anatomy in general but from BP as well (male Chiropractic student)</p> <p>I think everyone creates their own environment so it’s very efficient even though at the start it’s very awkward. Some people may not realize they are actually a hands-on person. It’s not just benefiting anatomy, it’s [benefitting] everything. I realize I’m more of a picture person so I try to summarize everything from the textbook and put it into an image. They create their own way that’s more efficient that just read and read and read (male Chiropractic student)</p>



**Table 4** Summary of themes and comments made in three focus groups of Royal Melbourne Institute of Technology health science students ( $n = 13$ ) regarding the potential barriers or caveats to their participation in Body Painting activities

Theme	Potential barriers or caveats to this learning strategy
<i>Not all student will participate in self-directed BP activities, though more students will participate over time</i>	<p>I'm from the [United] States and we got spoon fed, that's how we learned. And I came over here and I had a really hard time because it's not the same. I would have done a lot better if I wasn't spoon fed my whole life through learning, and [lecturer] doesn't spoon feed you—she tells you what you need to know and she says here's your prac, go through it, and if you have any questions ask me (female Biomedicine student)</p> <p>I think it takes a more creative and highly enthusiastic student to get involved with it. That's why you do get quite a lot of students who don't get involved in body painting as much. If you're a student who wants to get the most out of it, it works really well, and it helps your learning. But for students not wanting to get the most out of it, it's not gonna help (male Biomedicine student)</p> <p>I put on the paper in the beginning that I'm Muslim. I'm not covered in my head, I'm a Muslim mother but I am painting other people. I never do it on my own body but when I started in the beginning we did it together for posterior muscles of the forearm for one of my friends. And after finishing I was thinking to myself it's a good feeling because you learn it, you spend time reading, memorizing, looking at the textbook, the atlas and the prosections, but when you do it on your own it's different. And after that I am trying to be involved more. Last week we did it together—she did my foot bones painting – and you know it's encouraging me. I was one of them who said I'm never doing this but I did (female Biomedicine student)</p> <p>I don't want to lift up my shirt so that somebody can paint my stomach. I have a flabby tummy I don't want people to see that. And I think that's how everybody felt about it. Arms and legs is one thing but when you start talking about the back and the gluts and stuff. I saw one girl get her gluts out and I was like I couldn't do it, she's much braver than I am. I probably wouldn't volunteer to be painted but I would volunteer to help paint because being self-conscious. I think that's one thing that probably pushed a lot of people away (female Biomedicine student)</p> <p>The first couple of weeks everyone was a bit hesitant, but once the first person did it, everyone thought it's not so bad and they did it as the weeks go by. And every week we have someone different being painted in our class (male Osteopathy student)</p>
<i>BP takes time to do</i>	<p>I can paint, but I might paint badly, but I'll paint accurately. It might not be beautiful but I know where they are. But to achieve the accuracy I have to know where they are and how they work, what's the shape, how big, where's the position. Where's it located in the arm, leg, wherever. This is very different from textbooks so we have to get some time to get used to it (male Chiropractic student)</p>
<i>BP works best as a supplementary activity</i>	<p>BP was a fantastic thing to have but it was one of several good things in the [prac] room (female Osteopathy student)</p> <p>I think the important thing is that as long as it's not considered as an entire replacement, but it's considered as a supplement. One week it might work for you to write stuff but then next week you get to a different topic and you're trying to take sense of it, and it's not working, so you need to look at it differently, which is where I think people get the most out of BP (male Chiropractic student)</p>

The focus group discussion described key aspects for why BP assisted students to learn SA. In summary, BP was a group-based, self-directed learning approach supported by tutors and the lecturer. This self-directed learning, over time, led students to more strongly engage with anatomy course content, while learning with other students and tutors helped identify and confirm the correct anatomical knowledge. In addition, BP required students to practically apply textbook and other didactic knowledge on a real live person by taking the time to identify the muscles, tendons, blood vessels, and other SA through palpating, movements, and other practical classroom aids, and then using markers and color paints to differentiate the various anatomy —“learning by doing”.

One student commented:

The way I used to study might seem quite didactic. I made sure that I sit down and I write for approximately 2 hours or whatever. But now, I'm drawing and labeling things because that's one of the things that really helped me with anatomy. 'Cause my anatomy book, half of it is just page long images. Not only am I proud of the work that I'm doing, but it's so much easier too. I remember where everything is, and what I have to know and what order it's in. And I can throw that into my other subjects that I'm doing and it compliments my learning ability. I've definitely taken something away, not only from anatomy in general but from BP as well (male Chiropractic student).

**Fig. 1** Body painting activities in anatomy practical classes. **A, B** Landmarking process where bones, outlines, and muscle fibers are initially drawn in using whiteboard markers. This was often the most educational part of the BP process. **C, D, E** Body painting carried out for all areas of musculoskeletal anatomy, shoulder, thigh, forearm, and by all cultural groups



Another student commented:

It was nice having other people around, I wasn't the only one that didn't understand it. Having someone else talk it through with you, physically show you it, it really helped. It helps you learn, how to learn with other people (female Biomedicine student).

BP allowed students to learn surface anatomy on a living person, usually after first investigating with textbooks and cadavers, along with palpating the muscles and using color to differentiate the surface anatomy helping students to learn, understand, and remember. As a student commented:

**Fig. 2** Body painting in anatomy classes and by professional groups. **A, C** Body painting was a group activity in each anatomy practical class. Students were proud to be photographed at the end of each session. **B** Body painting by radiographers from Townsville Hospital. **D, E** The LA County Coroner being body painted at the British Institute of Embalming Conference in Melbourne, Australia 2016





In the textbook everything is so neat and set out and separated and then you get in there and it's what the hell is that? When you do the BP you have to feel it, you have to palpate, all that kind of stuff, and it really does cement that kind of learning. If you go to a prosection or a textbook, you think that doesn't look like that at all. When you feel it on a person you go 'yeah, I can kind of feel how that fits in there' (female Chinese Medicine student).

BP also allowed students to practice palpating different individuals, each with differences in their surface anatomy. With regard to palpating the muscles, a student mentioned:

You need that exposure. When we finish this course, we need to know what someone who has more muscular muscles feels like, how the muscles are, their range, how far they extend. It's good that we even get to have that practice, even doing the palpating with the BP. Otherwise if we don't get that practice, when we're in the real world we're going to freak out, keep seeking advice from our mentors or keep referring to textbooks rather than relying on our own experience (male Chiropractic student).

Another student commented:

And you learn how to palpate, how to touch. Learn and find for example where this muscle is sitting, palpate it, like a future patient for you. It's very good when you know what the movement is for example, abduction, adduction, supination, pronation. You have some idea about some muscles, but when you palpate it, you feel it. This muscle is doing this, and this muscle is doing that (female Biomedicine student).

Thus, students appreciated working on living people as a way to understand and strengthen their anatomy knowledge relevant to their future professions.

The use of color was also a good tool for learning, understanding, and remembering. One student commented:

When I'm painting by colour, I show the different structures, tendon, muscles. I do believe this painting in my opinion mixed with looking at the prosections, in picture or alive in the lab together it's very strong – very helpful to understand the concepts of anatomy. And, in terms of learning, I think it works really well. If you're getting painted, pointing and naming all muscles as you are doing it, helps you learn (female Biomedicine student).

Another student commented:

[Lecturer] is really, really, good at it [surface anatomy]. So, something that someone did in one solid colour, she'd look and say 'well, you can tell the

tendons here' and she'd make the colour different there. Now I know that this is definitely a tendon because she painted it on there as a tendon rather than one solid colour. I like the more detail, which you have to like art to do. The more detail you put into it, the more you understood it. The more time you spend on something, the more it sticks in your brain (male Biomedicine student).

This participation in BP led to students achieving learning benefits directly associated with the anatomy course — retaining a stronger memory of the position of bones, joints, muscles, actions, and insertions and a deeper understanding of anatomy — as well as longer-term benefits of wider practice with palpating the different sized and shaped bones and muscles of different people, and recognizing the value of including different learning approaches (visual summaries, tactile learning) into their university study and future life-long learning. These key aspects are summarized in Fig. 3, and a more detailed description of the key themes is provided in Table 3 along with those student comments which well capture the identified key themes, taken verbatim from the transcripts.

However, it was commonly observed that not all students participated in BP activities. The potential barriers or caveats to participation in BP activities were also explored in the focus groups, with these summarized in Table 4.

## Discussion

This study provides both quantitative and qualitative data not previously available regarding the value and mechanisms by which BP assists student learning of surface anatomy. The findings show that the majority of students in this study, undertaken towards the end of the course, reported a preference to learn surface anatomy (SA) via self-directed, group-based experiential learning activities, such as those involving BP, and that almost three-quarters of the students reported BP helped them learn anatomy "quite a bit" or "very much".

This study supports the use of student-centered teaching and learning methods including flexible, experiential, and self-directed learning [35]. Student-centered teaching is a powerful approach that moves the focus from the teacher to the student, encouraging active, energized, and engaged learning. Other studies have also shown most students appear to prefer hands-on, group-based, practical teaching activities to learn anatomy [36, 37]. In addition, the teaching of surface and internal anatomy has previously found to have benefited from a range of experiential learning strategies: drawing [11, 38, 39]; radiology [40]; ultrasound imaging [41–43]; Web-based and virtual methods [41, 44, 45]; visual

arts [46]; clay modelling, Play Doh, and white-boarding [14, 17, 39]; and BP [15, 17, 20–28]. The study findings and other associated literature suggest that adding BP activities with a significant level of experiential learning to anatomy practical sessions would complement the more traditional practical session approach involving individually focused examinations of laboratory prosections.

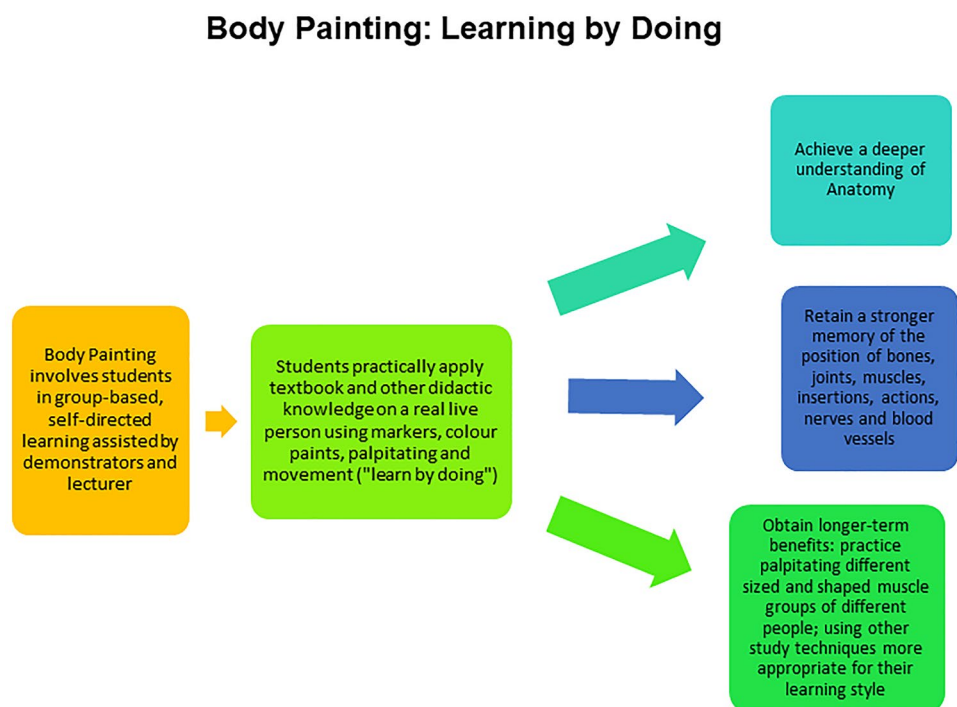
Students in the present study also reported high-level bonding and interaction with peers and tutors during BP activities, and that the BP activities provided motivation and enjoyment of anatomy learning. Peer learning was an important part of the BP experience for students in this study—as consistent with “Engagement Theory”—students were engaged in meaningful, collaborative learning activities involving peer interaction to achieve deep learning [31, 32]. These study findings confirm those obtained in an earlier study at a regional Australian University [14, 17], showing the addition of BP activities significantly improved medical and health science students’ engagement with teachers and peers to assist anatomy learning and long-term anatomy knowledge and understanding. It has been proposed that learning activities actively involving drawing of surface anatomy provide students an immediate enjoyment of anatomy; which in time lead to improved engagement and deep learning [14, 17, 39]. Enjoyable and fun anatomical learning activities are known to result in improved engagement, consistent with reports in both science [47] and education teaching [48].

The present study also identified the three key factors behind *why* many students believed BP activities helped

them learn surface anatomy — (1) by helping students integrate textbook and other knowledge onto a real live person; (2) reach a deeper understanding of human surface anatomy; and (3) remember the muscles, bones, joints, and other aspects of surface anatomy. These key factors can be summarized as BP helping students to sequentially “learn the correct names and positions of surface anatomy on the human body” → “understand how the surface anatomy functions” → “remember the names and positions of the surface anatomy”. This “learn” → “understand” → “remember” impact on students from the BP activities was also strongly represented in the qualitative findings.

Students reported the BP activities helped them learn the correct names and positions of surface anatomy on the human body because the activities were undertaken in friendly collaboration with the other students, tutors, and lecturers. The BP activities were often the first time students had experienced self-directed, group-based learning. The self-directed learning helped students actively and enthusiastically engage in their own learning — often using drawing and pictures to supplement the BP—while the group-based learning aspect with tutors and the lecturer present helped students learn correctly. Thus, the self-directed, friendly group collaboration created an engaged learning environment wherein students developed their skills in “learning how to learn” — that is, becoming more confident in undertaking self-directed learning, while the input from the other students, tutors and lecturers helped students learn the names, positions, and other aspects of human surface anatomy correctly.

**Fig. 3** Summary of the key findings of focus groups with first-year chiropractic, osteopathy, and Chinese medicine students and second-year biomedical science students to explore in-depth the key factors underpinning how body painting helped them learn surface anatomy. Group-based, self-directed learning assisted students to consolidate anatomy learning, taking it from books and cadavers to living human beings, thus achieving development of physical examination skills, and long-term retention of anatomical knowledge



However, while BP was an engaging and productive learning exercise for participating students, it should be pointed out that not all students took part in this activity. Students who did not take part stated that they did not have time to dedicate to BP or that they did not feel confident in their drawing. Although BP is not an obligatory activity, future studies may examine the students that did not participate in BP to assess whether there may be approaches that could be employed to cater for their needs, although we acknowledge that BP will not suit all students and that other innovative approaches may be used instead [14, 17]. As anatomy practical classes were not obligatory, many students did not participate in BP as they were absent from many of the practical classes and did not participate in any practical activities. Interestingly, many students were not keen on the BP at the start of the semester; however, their views often changed significantly as the semester progressed and most of these students became active and enthusiastic participants in BP by the end of the course.

BP is not used at all universities as an instructional activity as it requires expert training of academic staff and tutors. The first author ran a Tutor Training Workshop twice a year to share this experience, and to ensure that tutors were trained to provide positive guidance to students in the process of BP, which often involved demonstration of palpation, landmarking, and painting techniques.

Body painting is a powerful and engaging tool for learning surface anatomy, and the quantitative and qualitative data obtained in this study are supportive of continuing its current use in anatomy education in Australia. Since 2010, body painting has been a key component in the anatomy curriculum for all teaching delivered by the first author at JCU, RMIT University, La Trobe University, and currently at CSU. At CSU, BP was used as part of the curriculum, even during the 2020 COVID-19 pandemic where anatomy teaching was delivered *exclusively* online. At CSU in 2020, anatomy was delivered effectively for a head and neck anatomy subject using pre-recorded videos combined with encouraging students to use innovative learning approaches, including body painting at home [49]. Students were receptive to the innovative learning challenge while in self-isolation and lockdown and several students shared pictures on the subject page of their body painting efforts on their children's faces [49].

## Limitations

While the same survey instrument was used across three consecutive cohorts of Chinese medicine, biomedical science, and chiropractic and osteopathy students of the RMIT University to improve the reliability of findings, the survey itself was based on one used in a previous BP study at the JCU [14] that was not evaluated for validity or reliability.

In addition, it was not possible to use a comparative study design involving an intervention group of students who participated in BP activities versus a control group of students who did not, as Australian University research ethics committees do not allow this due to the possibility of students potentially being academically disadvantaged by not participating in BP activities. A further limitation of this study is that the data was self-reported, with students self-assessing how body painting assisted their recall and learning of anatomy week-to-week, over the semester, and leading into their exam study periods, that is, their “longer-term” memory. Therefore, the phrase “longer-term memory” used in this study only denotes memory and recall of anatomy over the semester and not into later years or future career. However, the focus group transcripts found students who participated in BP were able to clearly articulate that BP assisted them with their memory and recall of anatomy at least in the shorter term (over the duration of their course).

In addition, another issue of the data only being student self-report is that objective academic achievement scores were not also investigated. However, the first author anecdotally observed that students participating in extra-curricular BP projects were mostly the high achievers, tending to obtain distinctions (75–84%) and high distinctions (85–100%) in the subjects. Although final marks were not attributed unequivocally to participation in the BP projects, the high achievers were more likely to self-select into the BP student cohort, so it was inferred that participation in BP played some role in their success [50]. Future comparative longitudinal studies will therefore examine how students who participated in innovative anatomy teaching activities such as BP may have increased longer-term (6–12 months) knowledge and recall of anatomy teachings, as well as higher academic achievement scores, than students who did not participate in these activities.

## Conclusion

This study provides novel and strong qualitative and quantitative evidence regarding the ways in which BP assists students to learn surface anatomy, evidence which advocates for the inclusion of BP strategies as a standard component of anatomy practical sessions. The inclusion of BP in anatomy practical classes can provide new perspectives towards teaching anatomy to students who prefer more hands-on, visual, kinesthetic, and/or group learning activities. For many students, BP activities provide a more engaging, motivating, inspiring, and enjoyable environment for student learning, and assists them to develop deeper understandings of how surface anatomy “works” in a human body, as well as better remembering of the names, positions, and other aspects of human surface anatomy. When used in conjunction with wet anatomy classes, the innovative BP approach appears

to promote stronger learning engagement, more correct knowledge, deeper understanding of function, and longer-term memory retention of human surface anatomy. Thus, BP achieves a “learn” → “understand” → “remember” impact on students’ learning of surface anatomy.

**Funding** RMIT University STeLR Grant.

## Declarations

**Ethical Approval** RMIT Human Ethics Committee (ASEHAPP 16–13).

**Informed Consent** Implied consent was obtained from all individual participants included in the study by completion of the survey.

**Conflict of Interest** The authors declare no competing interests.

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