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Beyond “YouTube clips”: a qualitative study of manual therapy educators’ perceptions of 3D technology in MT education

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ABSTRACT

Objectives: Three-dimensional (3D) technologies such as virtual reality (VR) may facilitate the teaching and learning of manual therapy (MT). Teachers play a pivotal role in determining how new tools and technology are adopted and applied in the curriculum. Moreover, educators’ feedback can guide the development of tools tailored to MT training needs. This qualitative study aimed to explore MT educators’ perceptions of current teaching methods, the role of 3D technologies in MT education, and the barriers and enablers to their integration.

Design: In-depth interviews; data were analyzed using thematic analysis.

Setting: online.

Participants: 13 educators (9 males, 4 females; 10 physiotherapy, 3 osteopathy) from five different countries participated in this study.

Results: Five themes were identified that appeared to influence participants’ perception of the role of technology in manual therapy education. These were (1) Teaching strategies in MT, (2) Paradigm shift in MT education, (3) Complexities in teaching MT – Tacit and embodied challenges of palpation and specificity, (4) Role of educators in MT education and (5) Future directions and technological integration in MT education. These five themes collectively highlight both the challenges and opportunities in MT education.

Discussion and conclusion: The participants not only critiqued the current teaching methods employed in MT but also their role as an MT educator. While acknowledging the paradigm shift in MT education, participants believed that emerging technologies such as VR are transformative tools for MT education. Future research to explore the added utility of technology such as VR to traditional teaching methods is required.

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Manual therapy education; virtual reality; educator perceptions; curriculum integration; qualitative research

Background

Manual therapy (MT) is a specific hands-on approach used by health professions such including physiotherapy and osteopathy. The process of learning clinical MT skills has often been described using the ‘See one, do one, teach one’ approach, in which the learners are expected to progress toward independence after observing an expert clinician or teacher [1]. The teacher or expert then evaluates the learner’s technique and provides feedback. By providing feedback and guidance, it is believed that this approach helps learners to grasp the varied physical examination, palpation, and treatment [2]. Nevertheless, it has been criticized for lacking structured feedback to students and supervision, making it an inadequate standalone teaching method [1,3].

To address these limitations, emerging 3D technologies such as virtual reality (VR), augmented reality (AR), and mixed reality offer promising solutions to address the limitations of traditional MT education [4,5]. VR creates an immersive environment, while AR overlays virtual elements onto real-world settings [6]. When combined with haptic feedback devices, these technologies can replicate realistic clinical scenarios, allowing learners to develop skills in a controlled, safe environment [7]. For example, haptic systems enable users to interact with virtual objects, providing a tactile experience crucial for mastering MT techniques. Therefore, these technologies may have an important role in MT education as students must learn complex skills such as palpation of

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soft tissues, assess joint range of motion, and perform physical examination [8,9].

The COVID-19 pandemic further complicated MT education, forcing institutions to adopt online or hybrid learning methods [10]. This shift posed significant challenges for hands-on disciplines like MT, emphasizing the need for alternate learning tools [4]. Understanding the perspectives of MT educators regarding the role of digital technology is critical to shaping its integration into MT education. Teachers play a pivotal role in determining how new tools and technology are adopted and applied in the curriculum [11]. Their insights can help identify practical challenges such as aligning technological solutions with pedagogical objectives, maintaining a balance between hands-on and virtual training, and managing the resource demands of implementing advanced technologies [12]. Moreover, educators' feedback can guide the development of tools tailored to MT training needs, ensuring that technology enhances rather than replaces the essential human elements of teaching and learning [4]. Educators also act as role models for their students, influencing their attitudes toward technology [13]. A positive perspective from educators can foster openness and enthusiasm among learners, ultimately facilitating the successful adoption of innovative methods [14].

Educators' beliefs and attitudes toward technology are shaped by broader professional belief systems, including how they conceptualize the body, pain, and appropriate models of care [15,16]. These belief systems may influence not only whether new technologies are adopted, but also how they are framed, used, and modeled for students within MT education. By prioritizing the views and experiences of MT educators, institutions can create a more effective and collaborative framework for integrating 3D technology into MT education. This study therefore explored MT educators' perspectives on contemporary MT education, with particular attention to how emerging 3D technologies may complement existing teaching approaches in MT.

The aim of this qualitative study was to (1) investigate the perceptions of current teaching methods by MT educators; (2) the perceived role of 3D technologies in MT education; and (3) identify barriers and enablers for utilizing 3D technologies as part of MT education.

Methods

We followed the Consolidated Criteria for Reporting Qualitative Studies guidelines for reporting this qualitative research [17]. Ethical approval for the study was provided by Institutional Research Ethics Committee

(WTLR32200721). All participants signed an informed consent form prior to participation after reading the information sheet.

Study design

An exploratory qualitative research design using semi-structured interviews was used. The exploratory approach was considered appropriate to enable an in-depth understanding of current teaching methods in MT and the use of 3D digital technology in MT education by MT educators [18].

Participants

Potential participants were identified through professional networks, discipline-specific membership organizations, and institutions known to deliver MT education. Invitations were distributed via e-mail to professional bodies and academic programmes (physiotherapy, osteopathy, and chiropractic) in New Zealand and internationally. MT educators who met the inclusion criteria and expressed interest were invited to participate. Participants were included if they were registered MT practitioners (physiotherapists, osteopaths, or chiropractors), were currently teaching MT in a New Zealand or equivalent international institution and were willing to participate in the interview. Participants were excluded if they were not registered with a professional body or had not been teaching MT within the preceding 2 years. Of the 35 educators who were eligible, a convenient sampling was used to recruit 13 MT educators working in different institutions across the globe. Although no formal stratification or purposive sampling strategy was employed, efforts were made to capture variation in professional background, years of teaching experience, institutional context, and geographical location. The demographic information of participants is provided in Table 1.

Data collection

The primary investigator, a practicing osteopath, academic/MT educator with a PhD, and experienced in qualitative research methods, conducted most of the semi-structured interviews via Zoom between Jan 2022 and June 2023. A research assistant with experience in interviewing and qualitative research conducted interviews with a few other participants.

An interview guide (appendix 1) was developed and used based on professional experience and findings from the literature [4,19–21]. The interview guide consisted of questions about current teaching of MT; use of technology in MT education; perception about the role of 3D technologies in MT education; and any barriers and facilitators influencing the use of 3D

Table 1. Participant demographics.

Gender	9 Males 4 Females
Country	9 New Zealand 1 Italy 1 UAE 1 USA 1 Australia
Profession Teaching in	10 Physiotherapy 3 Osteopathy
Teaching Setting	13 All of the above
Group demonstration	
One-to-one demonstration	
Online	
All of the above	
Current usage of 3D technology (e.g. VR, AR, etc)	13 No
Any technology use in MT education	13 Yes (e.g. Youtube, Canvas, Powerpoint, self-prepared course materials/videos)

technologies in MT education. A pilot interview was undertaken with an experienced MT educator (23 years of experience) before data collection to ensure sufficiency and depth. Following the pilot interview, minor amendments, such as rephrasing of questions (as appropriate), were made to ensure clarity. The average duration of the interviews was 45 minutes. To facilitate data analysis, field notes including tone/gesture/animated responses were taken during the interview. All interviews were audio and video recorded and transcribed verbatim. The transcripts were sent to participants for member checking.

The richness of data that was generated (data sufficiency) and the rigor of the analytical process (analytical sufficiency) [22,23] determined the number of interviews required. Data collection ceased once data sufficiency (saturation) and analytic sufficiency were deemed to have been achieved, such that additional interviews were unlikely to yield substantially new insights relevant to the study aims. Therefore, data collection was stopped after 13 interviews which captured a diversity of viewpoints that enabled analytical sufficiency. Memos written at data collection and throughout the analytical process facilitated researcher reflexivity and highlighted and clarified key points that supported the identification of emerging codes confirming data sufficiency [24,25].

Data analysis

The data analysis was informed by a constructivist epistemological position, recognizing that participants' accounts reflect socially and professionally situated meanings of MT education and technology use. Data were analyzed using the approach of reflexive thematic analysis as described by Braun and Clarke [26] to explore patterned meanings across the dataset. Each interview set was initially analyzed independently by two investigators. Initial coding was undertaken and assisted by NVivo V.10 qualitative analysis software developed by QRS International. Reading and rereading the transcripts/memos/field notes looking for patterns in the

data (such as differences and commonalities) was done, resulting in category and theme development. Two investigators independently coded and then compared the initial coding for patterns and themes. Differences in coding and interpretation were explored through reflexive discussion, with attention to how each researcher's background and assumptions shaped analytic decisions. Our research team included members from diverse disciplinary backgrounds, including physiotherapy, osteopathy and nursing. Further, the team's experience levels ranged from research assistants and lecturers to professors. Our multidisciplinary approach with variations in roles and expertise allowed for a rich interpretation of the data while promoting reflexivity throughout the study. These discussions were documented through analytic memos and used to refine theme development. Category and theme development from the initial codes was an iterative and analytical process that involved moving beyond surface-level topic similarity to identify conceptually distinct themes [27]. The themes generated were assessed by a third investigator, who is an expert in qualitative research, for plausibility and explanatory values against the transcripts. While some themes were related, each captured a different analytic focus: Theme 1 addressed pedagogical strategies used in MT teaching; Theme 3 foregrounded the tacit and embodied challenges inherent in teaching manual skills; Theme 4 focused on educators' relational and evaluative roles; and Theme 5 captured future-oriented reflections on the integration of technology. This process helped minimize conceptual overlap while retaining the interconnected nature of educators' experiences. The key categories (factors) along with the themes, subthemes, and supporting quotes are presented in Table 2.

Findings

Five themes were identified that captured the views and opinions of participants about current teaching of MT and the role of technology in MT education. These were:

Table 2. Themes, sub-themes and supporting quotes of participant's perception about 3D technologies in manual therapy education.

Themes	Sub-Themes	Quotes
Theme 1 Teaching Strategies in MT	Structured and level-dependent teaching methods	<p>'So we went through different techniques, sagittal techniques, lateral techniques, frontal techniques; so extension, flexion, rotation, and different techniques . . . whether it could be the height of the bed, it could be the patient position, it could be the clinician position, it could be the line of drive or their angle of their hands, or the force that they're applying' (P4).</p> <p>'I have had to pare it back significantly and realise that we need to even break those steps down more for them. Because [students] are novice and inexperienced with handling patients. That might be with students I have on clinical placements, post grad students on clinical placement' (P1).</p> <p>'a good way I like to teach manual therapy . . . depends on who I'm teaching – so third years or post-grads depending on what level you go in' (P2).</p> <p>'I would demonstrate a procedure then break the procedure to smaller bit so learners can understand, and they would break into small groups of three to practice' (P3).</p>
	Interactive and hands-on teaching techniques	<p>'We show them how to do it then we watch them do it, then we might do it on them, so they feel what it feels like and we continually give them feedback in practical sessions. That's currently how we do it' (P8).</p> <p>'I show them what to do, then they try it before I come in and correct them' (P2).</p> <p>' . . . I would describe it has two functions: one is more of a theoretical philosophical component [then] I talk about the patient and what you look for in that manual therapy encounter. This provides students to interact before any techniques' (P7).</p> <p>' . . . and then we would demonstrate that procedure on a patient, or on a model . . . we would break up into groups and practice on each other, and then we'd also have videos of the procedures in the background as well' (P4).</p> <p>'I like to listen to other people even if they are students, colleagues, or whatever, even if I'm explaining, because I believe the learning environment is not only limited to one person' (P5).</p>
Theme 2 Paradigm shift in MT education	MT as part of continuum of care	<p>'Manual therapy is just one of your tools in your tool kit that you can use. It's not the be all or end all. It's important and we can use it selectively with patients but it has to be used in conjunction with other components like patient education, patient exercise, therapeutic alignments, all those other things' (P1).</p> <p>'Whether it's examination, whether it's treatment, whether it's exercise, rehab, whatever it is we're doing, it is part of the whole manual therapy continuum. Manual therapy is one more tool and this needs to be emphasised early on in their student journey' (P9).</p> <p>'I have come to an understanding that MT works best when used along with other approaches, say exercise or rehab. It is a part of care for me and not the only approach' (P12).</p> <p>'I emphasise to students to think broadly and consider what is appropriate for patient care. If it is something other than manual therapy, then use that' (P3).</p>
	Emphasis on clinical reasoning alongside technical skills	<p>'Rather than just looking at the mechanics of the technique itself actually looking at the application of the technique, in terms of the clinical setting. But certainly, I think having the clinical reasoning behind the specific manual therapy is really important. Knowing when to apply a particular technique or procedure is really important. They need to have that clinical reasoning' (P4).</p> <p>'Sometimes learners are focussed on getting that technique right, but, I make think why they chose that technique in the first place' (P3).</p> <p>'We will try to include the clinical reasoning process around it, as well as the procedure itself, and then practice those techniques' (P8).</p> <p>'We have clinical reasoning debate about theoretical perspective, then question and answers. This gives them an opportunity to clarify any doubts they may have' (P10).</p>
Theme 3 Complexities in teaching MT	Palpation and specificity challenges	<p>'Our practical component tends to be less specific than a lot of manual therapy it's true to say. We don't include palpation necessarily, particularly intersegmental and specificity of segments as they are complex. But I find teaching gross skills such as holding someone's hip to be easier' (P4).</p> <p>'The trouble is when those skills start to get a bit harder so things like HVLA and those type of things. That's where the students and staffs equally find it hard' (P9).</p> <p>'If we're doing PAs through the muscle trying to palpate the facet joint that's probably me telling them where they are if they're palpating. I closely watch them doing it' (P2).</p> <p>'For complex techniques such as mobilisation or manipulation, I may put my hands on top of them, so I know what they are doing and how much force is being applied etc' (P13).</p>
	Balancing theoretical and practical components	<p>'When I teach it I think that I have a duty to offer theory, theoretical knowledge, practical hands on skills and also ethical and perspective that helps the students to grow as a person and as future clinicians' (P 10).</p> <p>'Theory is very important as it underpins what we do. So, I do spend sometime explaining different theories and how things have evolved over time' (P5).</p> <p>'I show them the techniques, then revise the theoretical framework. After this, we discuss clinical scenario which I think will make them analyse deeper' (P13).</p>

(Continued)

Table 2. (Continued).

Themes	Sub-Themes	Quotes
Theme 4 Role of educators in MT education	Educator-student dynamics and feedback mechanisms	<p>'So, some people may be holding wrongly, or doing a level of movement on the body or the body position is not correct. So, you pick up things, and give feedback, and keep them going. So, it happens very quickly. it's a busy lab, so the feedback is limited.' (P6).</p> <p>'The main thing with manual therapy is the feedback. We can emphasise posture, we can emphasise handles, position through the traditional model that we're doing, we can use DVDs, videos, to say, 'Look, this is where you should be standing, so your shoulder should brace' (P11).</p> <p>'So we'd go through that, and then we'd problem solve if there are any difficult areas, or if I observed that there are any areas that people were doing incorrectly. Then we would go through and correct that, and problem solve any issues that they had with those particular techniques' (P4).</p>
	Reinforce, revise and measuring teaching success	<p>'Then we went through the objective of the neck with one of these things. I get them to tell me what they do next, and I'd ask why. Then I'd ask, what is that doing to the spine' (P2).</p> <p>'The actual manual technique itself, that takes time to learn and I don't think that can be done over one weekend. I think it's needs to be taught over a fairly lengthy period of time. I suppose just that reinforcement and going back over techniques time and time again' (P4).</p> <p>'One, is operational, that they have an understanding of three to five techniques that they could use in a body part or region that maybe appropriate for that patient in front of them. Operational. But the conceptual piece, too, and understanding, if I perform these techniques with my patient what sort of feedback should I see? As I assess that individual, how do I know if that is something successful for that patient to meet that? Those two things, if they can do that by the time they leave me and go to a terminal affiliation then I would consider that a success' (P7).</p>
Theme 5 Future directions and technological integration in MT education	Role of VR and 3D tools	<p>'Yes, I definitely do. I think that will be the next step away from just being the YouTube clips' (P11).</p> <p>'Yeah, for sure. I'm just not sure what could be used on that scale. I think it would be hard to tailor it specific to your course as well because I imagine that technology would be quite ingenious, I guess. Maybe more interactive things, interactive videos, interactive modules' (P9).</p> <p>I think it would if it provides some outcomes. If it meets outcomes, not directly, or at least indirectly. When I say indirectly if they do that, they are set up or geared up to a real world of people demonstrating could help further learning, and that leads to an outcome when they're assessed for the skills. It's a good outcome" (P6).</p>
	Potential of 3D and VR for enhancing skill acquisition	<p>'Yeah. I mean, I think it'd be great if you're able to do that. I think about the videos that we've done which is really just a 2D type thing, but if you can have much more of an idea of what's happening, and getting a gauge of the forces, the direction of movement, those sorts of things, would be fantastic' (P4).</p> <p>'If we teach it in the normal face-to-face situation we can offer and obtain a good performance, but if we want to have a learning we should have a retention after different times in the transfer, so I think that virtual reality can help us to understand and move towards this final goal (P10).</p> <p>'So that they can then watch their own hands afterwards. So that it's synchronous feedback, and I think if you can see it in 3D rather than just on a 2D video, that that would be helpful, this will enhance repeatability' (P8).</p> <p>'Create different environment where this movement could be applying as much as possible practice. This is useful because also using virtual reality you can put a lot of elements of the therapy encounter that can occur during the administration of the treatment' (P10).</p> <p>'Having access to VR would be great. I think, we can set up potential case scenarios and make assessments more objective. That is, the tool provides feedback as to whether the student has done the right palpation or not' (P3).</p>
	Barriers and enablers for using 3D technology in MT education	<p>'Availability would be the biggest barrier. If we had a company that said, we'd like you to try this, I think the people that teach the manual therapy we would all say, yeah, we'd love to give it a go, we'd love to give it a try. It would have to be something that allows multiple students to use it because we'll have 60 to 80 students in that manual therapy class. Access is a huge issue' (P7).</p> <p>'Cost. Technology is growing and more and more features, and how that would be upgraded and the cost and the budget, and so forth, and how many you could buy in terms of the numbers of students, and how many sets, and whether it is programmed to do one thing or many things, because we are dealing with multiple body areas, and the ranges and the complexity of the movement and the task and so forth' (P6).</p> <p>'I guess the flip side of that, like the expense, technology not being the their, people being into traditional teaching practises. I guess it's like anything really so hard to move on' (P9).</p> <p>'Yep absolutely, if there was adequate training, I would be very open to using it yeah.' (P2).</p> <p>'I don't have any experience in using the virtual reality for teaching. How that would work I really don't know, and that's my challenge' (P11).</p> <p>'Barriers, is probably just not knowing and not having the experience with virtual reality. So a balance, and that's a lack of experience in terms of the equipment' (P12).</p>

- (1) Teaching strategies in MT
- (2) Paradigm shift in MT education
- (3) Complexities in teaching MT: Tacit and embodied challenges of palpation and specificity
- (4) Role of educators in MT education
- (5) Future directions and technological integration in MT education

Theme one: teaching strategies in MT

This theme captures participant's views on current teaching methods and strategies used in MT education. Effective teaching combines structured methods, hands-on practice, and interactive learning. Further, peer review and ongoing reflection are critical for skill development.

Structured and level-dependent teaching methods

In this sub-theme, participants described various structured strategies they use to teach MT techniques to students. They thought that breaking the techniques into small steps was essential.

We demonstrate techniques, break them down into steps, and teach the steps. (P1)

By teaching the various steps, the participants believed that students would understand the technique better. This involves closely working with the student and assisting them with key parameters involved in the technique such as plane of motion, therapist position and so on.

So we went through different techniques, sagittal techniques, lateral techniques, frontal techniques; so extension, flexion, rotation, and different techniques ... whether it could be the height of the bed, it could be the patient position, it could be the clinician position, it could be the line of drive or their angle of their hands, or the force that they're applying. (P4)

Participants described adapting their teaching based on the student's capability and/or the year/level of the student (e.g. undergraduate vs postgraduate).

I have had to pare it back significantly and realise that actually we need to even break those steps down more for them. Because [students] are novice and inexperienced with handling patients. That might be with students I have on clinical placements, post grad students on clinical placement. (P1)

... a good way I like to teach manual therapy ... depends on who I'm teaching - so third years or postgrads depending on what level you go in. (P2)

Interactive and hands-on teaching techniques

Participants described utilizing a hands-on approach to their teaching and to make the session more

interactive. This may involve them demonstrating a technique first and then going around to check/assist their students performing the technique, which is consistent with a 'see-one, do-one' approach.

We show them how to do it then we watch them do it, then we might do it on them so they feel what it feels like and we continually give them feedback in practical sessions. That's currently how we do it. (P8)

I show them what to do, then they try it before I come in and correct them. (P2)

The participants described about how they make sessions 'interactive' by providing theory a clinical case scenario or relevant anatomical information first and then demonstrate the technique.

... I would describe it has two functions: one is more of a theoretical philosophical component [then] I talk about the patient and what you look for in that manual therapy encounter. This provides students to interact before any techniques. (P7)

... and then we would demonstrate that procedure on a patient, or on a model ... we would break up into groups and practice on each other, and then we'd also have videos of the procedures in the background as well. (P4)

By doing this, the participants provided opportunities for students to ask any relevant questions and enabled interaction while learning the techniques.

I like to listen to other people even if they are students, colleagues, or whatever, even if I'm explaining, because I believe the learning environment is not only limited to one person. (P5)

Theme two: paradigm shift in MT education

This theme captures participant's views on shift in paradigm in MT education. Participant's felt that there is a growing emphasis on integrating MT within a continuum of care. This approach aligns technical skills with clinical reasoning and patient-centered practices and emphasized a move away from MT being a standalone practice. Although participants' accounts primarily focused on current MT teaching practices, these discussions provided the context through which educators later reflected on the potential role of 3D and VR technologies.

MT as part of a continuum of care

In this subtheme, participants described that MT is part of a continuum of care rather than a standalone treatment approach. That is, MT alone may not be sufficient in-patient management.

Manual therapy is just one of your tools in your tool kit that you can use. It's not the be all or end all. It's important and we can use it selectively with patients

but it has to be used in conjunction with other components like patient education, patient exercise, therapeutic alignments, all those other things. (P1)

Participants believed MT was one of the tools in the kit and should be emphasized

Whether it's examination, whether it's treatment, whether it's exercise, rehab, whatever it is we're doing, it is part of the whole manual therapy continuum. Manual therapy is one more tool and this needs to be emphasised early on in their student journey. (P9)

Emphasis on clinical reasoning alongside technical skills

Participants described that clinical reasoning skill is important alongside technical skills to enable students to understand when to apply a particular technique or not.

Rather than just looking at the mechanics of the technique itself actually looking at the application of the technique, in terms of the clinical setting. But certainly, I think having the clinical reasoning behind the specific manual therapy is really important. Knowing when to apply a particular technique or procedure is really important. They need to have that clinical reasoning. (P4)

We will try to include the clinical reasoning process around it, as well as the procedure itself, and then practice those techniques. (P8)

The emphasis on clinical reasoning enabled the participants to have robust discussions about some of the theoretical underpinnings and provided an opportunity for students to communicate their queries or doubts.

We have clinical reasoning debate about theoretical perspective, then question and answers. This gives them an opportunity to clarify any doubts they may have. (P10)

Theme three: complexities in teaching MT – Tacit and embodied challenges of palpation and specificity

This theme highlights the tacit, embodied, and context-dependent nature of palpation and segmental specificity, which participants described as particularly difficult to teach using traditional MT instructional approaches alone. They discussed the various types of skills that need to be imparted including gross and fine skills required for different tissue palpation and techniques. Furthermore, the participants elaborated on the need to balance theory with practice and to tailor instructions to meet the diverse needs of learners.

Palpation and specificity challenges

Participants described the challenges they face while teaching tissue palpation. In this context, they expressed that teaching gross motor skills (e.g. holding a leg, examining a shoulder joint) that does not require deeper palpation skills was comparatively easier.

Our practical component tends to be less specific than a lot of manual therapy it's true to say. We don't include palpation necessarily, particularly intersegmental and specificity of segments as they are complex. But I find teaching gross skills such as holding someone's hip to be easier. (P4)

Conversely, participants found it challenging to teach techniques that required subtle palpation skills and/or specific segmental mobilisation/manipulation.

The trouble is when those skills start to get a bit harder so things like HVLA and those types of things. That's where the students and staffs equally find it hard. (P9)

The participants described using different strategies such as 'putting their hands-over' students' hands or, 'watching closely' to support the development of finer motor skills required for deeper/subtle palpation and performing complex techniques such as a spinal manipulation.

If we're doing PAs through the muscle trying to palpate the facet joint that's probably me telling them where they are if they're palpating. I closely watch them doing it. (P2)

For complex techniques such as mobilisation or manipulation, I may put my hands on top of them, so I know what they are doing and how much force is being applied etc. (P13)

Balancing theoretical and practical components

Balancing theoretical perspective with practical techniques/components was considered important for participants. Explaining theory was considered essential as practice can lack context, meaning, and adaptability without theoretical grounding.

When I teach it I think that I have a duty to offer theory, theoretical knowledge, practical hands-on skills and also ethical and perspective that helps the students to grow as a person and as future clinicians. (P 10)

Participants further described that combining theory with practice enables learners to analyze problems more effectively and develop solutions for their patients.

I show them the techniques, then revise the theoretical framework. After this, we discuss clinical scenario which I think will make them analyse deeper. (P13)

Theme four: role of educators in MT education

In this theme, participants expanded on their role as an educator which they viewed as a privilege and

responsibility, shaping the next generation of therapists. Feedback mechanisms and continuous development are central to their roles.

Educator-student dynamics and feedback mechanisms

In this sub-theme, participants described that a key factor for learner development is feedback provided by them. Some participants expressed frustrations in minimal time available for providing feedback.

So, some people may be holding wrongly, or doing a level of movement on the body or the body position is not correct. So, you pick up things, and give feedback, and keep them going ... it happens very quickly. it's a busy lab, so the feedback is limited. (P6)

On the other hand, some participants described ensuring dedicated time for providing feedback to learners. By doing so, participants had an opportunity to identify difficult areas for learners and problem solve those issues.

The main thing with manual therapy is the feedback. We can emphasise posture, we can emphasise handles, position through the traditional model that we're doing, we can use DVDs, videos, to say, 'Look, this is where you should be standing, so your shoulder should brace'. (P11)

So we'd go through that, and then we'd problem solve if there are any difficult areas, or if I observed that there are any areas that people were doing incorrectly. Then we would go through and correct that, and problem solve any issues that they had with those techniques. (P4)

Reinforce, revise and measuring teaching success

In this subtheme, participants explained the use of revision and reinforcement to provide opportunities for learners to practice their MT skills and to check their understanding.

Then we went through the objective [and] I get them to tell me what they do next, and I'd ask why. Then I'd ask, what is that doing to the spine. (P2)

... [its]the actual manual technique itself, that takes time to learn and I don't think that can be done over one weekend. I think it needs to be taught over a fairly lengthy period of time ... reinforcement and going back over techniques time and time again [is needed]. (P4)

Participants described how they measure the success of their teaching practice, which was considered critical for learning.

One, is operational, that they have an understanding of three to five techniques that they could use in a body part or region that maybe appropriate for that patient in front of them. Operational. But the conceptual piece, too, and understanding, if I perform these techniques with my patient what sort of feedback should I see? As I assess that individual, how do I know if that is something

successful for that patient to meet that? Those two things, if they can do that by the time they leave me and go to a terminal affiliation then I would consider that a success. (P7)

Theme five: future directions and technological integration in MT education

This theme captures educators' cautious and conditional views on the potential role of 3D technologies in MT education, particularly as adjuncts to existing teaching practices rather than replacements. Some participants believed that the use of 3D and VR technologies could meaningfully support skill acquisition, particularly in relation to visualization, repeatability, and feedback. In this context, participants felt that emerging technologies like VR and 3D tools show promise in enhancing learning. However, participants thought that comparative studies and addressing barriers like costs and access would be critical for widespread adoption.

Role of virtual reality (VR) and 3D tools

In this subtheme, participants expressed their opinions about the perceived role of technology in MT education. Generally, there was consensus that technology such as VR has a place and role in MT education.

Yes, I definitely do. I think that will be the next step away from just being the YouTube clips. (P11)

Yeah, for sure. I'm just not sure what could be used on that [large] scale. I think it would be hard to tailor it specific(ally) to your course as well because I imagine that technology would be quite ingenious, I guess. Maybe more interactive things, interactive videos, interactive modules. (P9)

Participant further described that technology may be useful if it can result in direct or indirect outcomes related to learning outcomes.

I think it would, if it provides some outcomes. If it meets outcomes, not directly, or at least indirectly ... they are set up or geared up to a real world of people demonstrating could help further learning, and that leads to an outcome when they're assessed for the skills. It's a good outcome. (P6)

Potential of 3D and VR for enhancing skill acquisition

In this subtheme, participants described how the use of 3D and VR technologies could revolutionize MT skill acquisition.

I think it'd be great if you're able to do that. I think about the videos that we've done which is really just a 2D type thing, but if you can have much more of an idea of what's happening, and getting a gauge of the forces,

the direction of movement, those sorts of things, would be fantastic. (P4)

Access to technology such as VR was perceived to play an important role in knowledge transfer and skill retention by participants.

If we teach it in the normal face-to-face situation, we can offer and obtain a good performance, but if we want to have learning, we should have retention after different times in the transfer, so I think that virtual reality can help us to understand and move towards this final goal. (P10)

Some participants thought that VR might enable repeatability for students and make assessments more objective.

So that they can then watch their own hands afterwards. So that it's synchronous feedback, and I think if you can see it in 3D rather than just on a 2D video, that that would be helpful; this will enhance repeatability. (P8)

Create (a) different environment where this movement could be applying as much as possible practice. This is useful because also using virtual reality, you can put a lot of elements of the therapy encounter that can occur during the administration of the treatment. (P10)

Having access to VR would be great. I think we can set up potential case scenarios and make assessments more objective. That is, the tool provides feedback as to whether the student has done the right palpation or not. (P3)

Barriers and enablers for using 3D technology in MT education

Participants identified various factors that were both barriers and enablers for using 3D technologies as part of MT education. Some participants felt that availability of the technology itself was a significant barrier if technology such as VR to be used in MT education.

Availability would be the biggest barrier. If we had a company that said, we'd like you to try this, I think the people that teach the manual therapy we would all say, yeah, we'd love to give it a go; we'd love to give it a try. It would have to be something that allows multiple students to use it because we'll have 60 to 80 students in that manual therapy class. Access is a huge issue. (P7)

Cost was identified by most participants as a major barrier for utilizing technology such as VR in MT education.

Cost. Technology is growing, and (there are) more and more features, and how that would be upgraded and the cost and the budget and so forth, and how many you could buy in terms of the numbers of students and how many sets, and whether it is programmed to do one thing or many things, because we are dealing with multiple body areas, and the ranges and the complexity of the movement and the task and so forth. (P6)

I guess the flip side of that, like the expense, technology not being there, (and) people being into traditional teaching practises. I guess it's like anything really so hard to move on. (P9)

Participants indicated that they would be keen to try technology if it was available. However, some required further knowledge about technology. They thought that using technology without completely understanding it, or if the technology did not work properly may discourage them from using it.

Yep absolutely, if there was adequate training, I would be very open to using it. (P2)

I don't have any experience in using the virtual reality for teaching. How that would work I really don't know, and that's my challenge. (P11)

Barriers are probably just not knowing and not having the experience with virtual reality. So, a balance, and that's a lack of experience in terms of the equipment. (P12)

Discussion

This study explored the perceptions of participants regarding the current teaching practices of MT education and the perceived role of technology in MT education. Furthermore, to identify the barriers and enablers for utilizing 3D technologies as part of MT education. The thematic analysis revealed five themes that collectively highlight both the challenges and opportunities in MT education. While one theme explicitly focused on 3D technologies, educators' reflections on teaching strategies, feedback, and the challenges of teaching tacit MT skills formed the foundation for their views on how such technologies might be integrated.

Teaching strategies in MT

Participants emphasized that effective teaching strategies in MT involve a balance of structured approaches, hands-on practice, and interactive learning. Structured teaching methods were highlighted as essential for breaking down complex techniques into manageable steps tailored to the learner's level. This aligns with previous literature emphasizing scaffolding in skill acquisition [28]. Additionally, the 'see-one, do-one' approach fostered experiential learning and iterative feedback, both of which are critical for developing competency in manual skills [29,30]. The participants further thought that the integration of theoretical discussions and clinical case scenarios further promoted a deeper understanding, which may allow students to bridge the gap between theory and practice. This is consistent with previous findings [31,32].

Paradigm shift in MT education

Participants acknowledged a growing paradigm shift in MT education, emphasizing the integration of MT within a broader continuum of care rather than viewing it as a standalone modality. This aligns with contemporary approach of utilizing MT as part of a multimodal and

patient-centered care [33–35]. Furthermore, the inclusion of clinical reasoning alongside technical skills was seen as crucial. The ability to discern when and how to safely apply specific MT techniques underscores the need for an educational focus that extends beyond procedural knowledge, fostering critical thinking and adaptability in clinical practice. This is in agreement with the recommendations made by Kerry et al. [33].

Complexities in teaching MT

Our findings highlight the role of educators in MT education, which was viewed by participants as both a privilege and a responsibility. Participants expressed that teaching MT involves significant challenges, particularly in imparting fine motor skills for palpation and specific segmental techniques. Participants noted that while gross motor skills are relatively easier to teach, the subtleties of deeper palpation require tailored strategies such as direct guidance (e.g. hands-on demonstrations). This is consistent with findings from other studies that highlight the complexity of teaching tactile skills [36,37]. This is also in congruence with the perception from students in our previous study [5], who reported that learning subtle palpation skills was harder and therefore required greater supervision and support from educators. Both educators in the current study and students in the previous study perceived that technology such as VR may enhance development of complex skills by delivering multi-sensory feedback [38,39]. Accordingly, our findings are consistent with studies that have shown 3D technology such as virtual reality may improve both gross and fine motor skills [40,41].

Role of educators and feedback in MT education

Feedback mechanisms were highlighted as a cornerstone of effective teaching by participants. However, the participants added that limited time available for detailed feedback in busy laboratory environments is a significant challenge. This perspective was also shared by MT students in a previous study in which tutor feedback was identified as a key factor for learners to use 3D technology in MT education [5]. Participants further emphasized the importance of iterative reinforcement, revision and lack of opportunity to practice as a limitation of current way MT is being taught. These findings concur with previous research which clearly indicate that practice influences student outcomes [42]. Measuring teaching success through both operational (skill proficiency) and conceptual (clinical application) outcomes were also considered important by participants in shaping competent therapists. Therefore, participants believed that technologies such as VR may be useful in creating objective assessments and can be used as a way to

determine teaching success. However, future research is required to verify these assumptions.

Educators' accounts revealed an ongoing tension between traditional craft-based approaches to teaching MT, which rely heavily on embodied demonstration and apprenticeship-style learning, and emerging multimodal and technology-supported approaches that aim to augment feedback and practice opportunities. This tension helps explain participants' cautious optimism toward 3D and VR technologies, which were largely viewed as adjuncts rather than replacements for hands-on teaching. These findings are consistent with learners' perspectives reported in a previous study examining the role of 3D technologies in MT education.

Future directions and technological integration in MT education

A number of factors were identified as barriers and enablers for using 3D technologies as part of MT education, including cost, knowledge about technology, accessibility and ethical issues, which are consistent with existing literature [43,44]. Differences in enthusiasm for 3D and VR technologies appeared partly shaped by educators' prior exposure to technology and comfort with digital tools, highlighting the importance of faculty development alongside technological innovation. This interpretation is consistent with findings from our previous qualitative investigation of MT learners, which similarly identified familiarity with digital tools as influencing perceived usefulness and acceptance of 3D technologies [5]. Further, it may be crucial for MT educators to share the clinical reasoning behind a physical assessment procedure, enabling the developer to integrate the software parameters that control the degree of physical tasks and challenges to meet the assessment/treatment needs as identified before [4,45]

To summarize, the participants not only critiqued the current teaching methods employed in MT but also their role as a MT educator. Participants viewed technologies such as VR as likely future adjuncts to current teaching methods, with potential to support feedback, enable more objective assessment, and reduce extraneous stress on learners. Future research may investigate the addition of technology to traditional teaching methods in improving outcomes of learners in terms of MT assessment, skills, techniques and patient safety.

Implications for MT learners, educators and teaching institutions

Educators in this study identified several specific challenges in MT education that they felt may be meaningfully supported by 3D technologies. These included difficulties in conveying force calibration and direction, visualizing joint, and soft-tissue movement during

techniques, and providing learners with opportunities for repeated, standardized practice accompanied by timely feedback. Educators also thought that a VR environment for example may help MT learners to develop and master their subtle palpation skills by observing their own hand positioning and movement patterns.

Our findings suggest that implementation of 3D/VR technologies may be successful if used as an adjunct to existing teaching approaches rather than as a replacement. This may include piloting small, targeted learning modules aligned with specific learning outcomes, investing in faculty development to build educators' confidence and familiarity with digital tools, and ensuring that any technological integration is clearly linked to clinical reasoning and multimodal models of care.

From a development perspective, participants highlighted several key features that may enhance the educational value of technological advances in MT education. This may include the development of feedback dashboards for MT learners, including realistic haptic feedback where possible. Practicability in a 'fail safe' environment may allow learners to explore errors safely without negative consequences and explicitly linked to learning objectives rather than performance alone. Such features may provide quality assurance processes for educators, institutions, and regulatory bodies. Participants also emphasized the importance of flexibility, allowing tools to be adapted across body regions, techniques, and levels of learner expertise, and of aligning technological outputs with how educators assess reasoning, decision-making, and patient-centered application of MT skills.

Strengths and limitations

To our knowledge, this is the first qualitative study to explore the perceptions of MT educators on the role of 3D technologies in MT education. The main strength of this study was that it was open to all MT educators. The participants came from different disciplines (physiotherapy and osteopathy) and different countries. This diversity in participants resulted in thick/rich data enabling transferability of findings to different context and countries. We followed a robust protocol to reduce bias and enhance credibility of the findings and used COREQ guidelines to improve transparency in reporting [46]. The study is not without its limitations. Although chiropractic educators were invited to participate, no responses were received. Consequently, perspectives from chiropractic education are not represented, which may limit the transferability of findings across all manual therapy professions. Future research should aim to include chiropractic educators to provide a more comprehensive understanding of manual therapy education. Despite this limitation we are confident that our data has captured different

perspectives and may be applicable to any profession that uses MT including chiropractic. Another limitation to acknowledge is convenience sampling, as MT educators with interests in education or technology may have been more likely to respond to the invitation to participate.

Conclusion

MT educators described tensions between traditional craft-based teaching approaches and emerging multi-modal strategies, which provided the context for their views on the potential role of 3D technologies. Some participants viewed these technologies as having the potential to meaningfully support skill acquisition; however, they were largely regarded as adjuncts rather than replacements for hands-on teaching. However, barriers such as cost, access, and lack of familiarity with these technologies were identified as significant challenges. Future research to explore the added utility of technology such as VR to traditional MT teaching methods are required.

Author contributions

CRedit: **Kesava Kovanur Sampath:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Writing – original draft, Writing – review & editing; **Cindy McIntyre:** Data curation, Formal analysis, Writing – review & editing; **Ashokan Arumugam:** Methodology, Writing – review & editing; **Oliver P Thomson:** Data curation, Formal analysis, Writing – review & editing; **Patrea Andersen:** Conceptualization, Methodology, Writing – review & editing.

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References

[1] Kotsis SV, Chung KC. Application of the “see one, do one, teach one” concept in surgical training. *Plast*

- Reconstr Surg. 2013;131(5):1194–1201. doi: 10.1097/PRS.0b013e318287a0b3
- [2] Speirs C, Brazil V. See one, do one, teach one: is it enough? No. *Emerg Med Australasia*. 2018;30(1):109–110. doi: 10.1111/1742-6723.12927
- [3] Romero P, Günther P, Kowalewski KF, et al. Halsted's “see one, do one, and teach one” versus Peyton's four-step approach: a randomized trial for training of laparoscopic suturing and knot tying. *J Surg Educ*. 2018;75(2):510–515. doi: 10.1016/j.jsurg.2017.07.025
- [4] Kovanur Sampath K, Arumugam A, Jull G. The role of 3D digital applications in manual therapy education – a scoping review. *Int J Osteopathic Med*. 2023;47:100645. doi: 10.1016/j.ijosm.2022.10.007
- [5] Kovanur Sampath K, Arumugam A, Yaghi E, et al. Perception and knowledge of learners about the use of 3D technologies in manual therapy education – a qualitative study. *BMC Med Educ*. 2023;23(1):509. doi: 10.1186/s12909-023-04497-6
- [6] Li X, Xu B, Teng Y, et al. Comparative research of AR and VR technology based on user experience. In: 2014 International Conference on Management Science & Engineering 21th Annual Conference Proceedings; 2014 (Helsinki, Finland) Aug; p. 17–19.
- [7] Kirkman MA, Ahmed M, Albert AF, et al. The use of simulation in neurosurgical education and training: a systematic review. *J Neurosurg*. 2014;121(2):228–246. doi: 10.3171/2014.5.JNS131766
- [8] Rabey M, Hall T, Hebron C, et al. Reconceptualising manual therapy skills in contemporary practice. *Musculoskeletal Sci Pract*. 2017;29:28–32. doi: 10.1016/j.msksp.2017.02.010
- [9] Sizer PS, Felstehausen V, Sawyer S, et al. Eight critical skill sets required for manual therapy competency: a Delphi study and factor analysis of physical therapy educators of manual therapy. *J Allied Health*. 2007;36(1):30–40.
- [10] Etoom M, Aldaher KN, AlAbed AA, et al. Distance learning in physiotherapy education during the COVID-19 pandemic: students' satisfaction, perceived quality, and potential predictors of satisfaction. *Physiother Theory Pract*. 2023;39(7):1513–1518. doi: 10.1080/09593985.2022.2042438
- [11] Wohlfart O, Wagner I. Longitudinal perspectives on technology acceptance: teachers' integration of digital tools through the COVID-19 transition. *Educ Inf Technol*. 2025;30(5):6091–6115. doi: 10.1007/s10639-024-12954-y
- [12] Bećirović S. Challenges and barriers for effective integration of technologies into teaching and learning. In: Bećirović S, editor. *Digital pedagogy: the use of digital technologies in contemporary education*. Springer Nature Singapore; 2023. p. 123–133. doi: 10.1007/978-981-99-0444-0_10
- [13] Saboor A, Khan MZ, Khan MN, et al. Exploring the factors that influence students acceptance and use of online learning technology in higher education institutes of Khyber Pakhtunkhwa Pakistan. *Educ Inf Technol*. 2025;30(13):18433–18460. doi: 10.1007/s10639-025-13543-3
- [14] Gibson PA, Stringer K, Cotten SR, et al. Changing teachers, changing students? The impact of a teacher-focused intervention on students' computer usage, attitudes, and anxiety. *Comput Educ*. 2014;71:165–174. doi: 10.1016/j.compedu.2013.10.002
- [15] Caneiro JP, Bunzli S, O'Sullivan P. Beliefs about the body and pain: the critical role in musculoskeletal

- pain management. *Braz J Phys Ther.* 2021;25(1):17–29. doi: [10.1016/j.bjpt.2020.06.003](https://doi.org/10.1016/j.bjpt.2020.06.003)
- [16] Houben RM, Vlaeyen JW, Peters M, et al. Health care providers' attitudes and beliefs towards common low back pain: factor structure and psychometric properties of the HC-PAIRS. *Clin J Pain.* 2004;20(1):37–44. doi: [10.1097/00002508-200401000-00008](https://doi.org/10.1097/00002508-200401000-00008)
- [17] Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care.* 2007;19(6):349–357. doi: [10.1093/intqhc/mzm042](https://doi.org/10.1093/intqhc/mzm042)
- [18] Chapman AL, Hadfield M, Chapman CJ. Qualitative research in healthcare: an introduction to grounded theory using thematic analysis. *J R Coll Physicians Edinburgh.* 2015;45(3):201–205. doi: [10.4997/jrcpe.2015.305](https://doi.org/10.4997/jrcpe.2015.305)
- [19] Hamilton D, McKechnie J, Edgerton E, et al. Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. *J Comput Educ.* 2020;8(1):1–32. doi: [10.1007/s40692-020-00169-2](https://doi.org/10.1007/s40692-020-00169-2)
- [20] Hu-Au E, Lee JJ. Virtual reality in education: a tool for learning in the experience age. *Int J Innov Educ.* 2017;4(4):215–226. doi: [10.1504/IJIE.2017.091481](https://doi.org/10.1504/IJIE.2017.091481)
- [21] Mącznik AK, Ribeiro DC, Baxter GD. Online technology use in physiotherapy teaching and learning: a systematic review of effectiveness and users' perceptions. *BMC Med Educ.* 2015;15(1):160. doi: [10.1186/s12909-015-0429-8](https://doi.org/10.1186/s12909-015-0429-8)
- [22] LaDonna KA, Artino AR Jr., Balmer DF. Beyond the guise of saturation: rigor and qualitative interview data. *J Grad Med Educ.* 2021;13(5):607–611. doi: [10.4300/JGME-D-21-00752.1](https://doi.org/10.4300/JGME-D-21-00752.1)
- [23] Vasileiou K, Barnett J, Thorpe S, et al. Characterising and justifying sample size sufficiency in interview-based studies: systematic analysis of qualitative health research over a 15-year period. *BMC Med Res Methodol.* 2018;18(1):148. doi: [10.1186/s12874-018-0594-7](https://doi.org/10.1186/s12874-018-0594-7)
- [24] Birks M, Chapman Y, Francis K. Memoing in qualitative research: probing data and processes. *J Res Nurs.* 2008;13(1):68–75. doi: [10.1177/1744987107081254](https://doi.org/10.1177/1744987107081254)
- [25] Mills J, Birks M. *Quality in Qualitative Research Qualitative Methodology: A Practical Guide* (London: Sage Publications Inc.). 2014. doi: [10.4135/9781473920163](https://doi.org/10.4135/9781473920163)
- [26] Braun V, Clarke V. Reflecting on reflexive thematic analysis. *Qualitative Res Sport, Exercise Health.* 2019;11(4):589–597. doi: [10.1080/2159676X.2019.1628806](https://doi.org/10.1080/2159676X.2019.1628806)
- [27] Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative Res Psychol.* 2006;3(2):77–101. doi: [10.1191/1478088706qp0630a](https://doi.org/10.1191/1478088706qp0630a)
- [28] Reekie M, de Bosch Kemper N, Epp S, et al. Learning pathways: levelling, scaffolding & mapping curriculum. *J Prof Nurs.* 2023;46:163–167. doi: [10.1016/j.prof.nurs.2023.03.006](https://doi.org/10.1016/j.prof.nurs.2023.03.006)
- [29] Kotsis SV, Chung KC. Application of the “see one, do one, teach one” concept in surgical training. *Plast Reconstr Surg.* 2013;131(5):1194–1201. Available from: https://journals.lww.com/plasreconsurg/fulltext/2013/05000/application_of_the__see_one,_do_one,_teach_one__52.aspx
- [30] LeCompte M, Stewart M, Harris T, et al. See one, do one, teach one: a randomized controlled study evaluating the benefit of autonomy in surgical education. *Am J Surg.* 2019;217(2):281–287. doi: [10.1016/j.amjsurg.2018.10.037](https://doi.org/10.1016/j.amjsurg.2018.10.037)
- [31] Elgheit REA, Nashat N. Bringing theory to life: integrating case-based learning in applied physiology for undergraduate physiotherapy education. *BMC Med Educ.* 2025;25(1):234. doi: [10.1186/s12909-025-06725-7](https://doi.org/10.1186/s12909-025-06725-7)
- [32] Jiang D, Huang D, Wan H, et al. Effect of integrated case-based and problem-based learning on clinical thinking skills of assistant general practitioner trainees: a randomized controlled trial. *BMC Med Educ.* 2025;25(1):62. doi: [10.1186/s12909-025-06634-9](https://doi.org/10.1186/s12909-025-06634-9)
- [33] Kerry R, Young KJ, Evans DW, et al. A modern way to teach and practice manual therapy. *Chiropr Man Therapies.* 2024;32(1):17. doi: [10.1186/s12998-024-00537-0](https://doi.org/10.1186/s12998-024-00537-0)
- [34] Keter D, Griswold D, Learman K, et al. Priorities in updating training paradigms in orthopedic manual therapy: an international Delphi study. *J Educ Eval Health Prof.* 2023;204–0. doi: [10.3352/jeehp.2023.20.4](https://doi.org/10.3352/jeehp.2023.20.4)
- [35] Lin I, Wiles L, Waller R, et al. What does best practice care for musculoskeletal pain look like? Eleven consistent recommendations from high-quality clinical practice guidelines: systematic review. *Br J Sports Med.* 2020;54(2):79–86. doi: [10.1136/bjsports-2018-099878](https://doi.org/10.1136/bjsports-2018-099878)
- [36] Hegedus EJ, Goode A, Campbell S, et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. *Br J Sports Med.* 2008;42(2):80–92. doi: [10.1136/bjism.2007.038406](https://doi.org/10.1136/bjism.2007.038406)
- [37] Nikendei C, Huber J, Stiepak J, et al. Modification of Peyton's four-step approach for small group teaching – a descriptive study. *BMC Med Educ.* 2014;14(1):68. doi: [10.1186/1472-6920-14-68](https://doi.org/10.1186/1472-6920-14-68)
- [38] Downer T, Gray M, Andersen P. Three-dimensional technology: evaluating the use of visualisation in mid-wifery education. *Clin Simul Nurs.* 2020;39:27–32. doi: [10.1016/j.ecns.2019.10.008](https://doi.org/10.1016/j.ecns.2019.10.008)
- [39] Jensen L, Konradsen F. A review of the use of virtual reality head-mounted displays in education and training. *Educ Inf Technol.* 2018;23(4):1515–1529. doi: [10.1007/s10639-017-9676-0](https://doi.org/10.1007/s10639-017-9676-0)
- [40] Hanson J, Andersen P, Dunn PK. Effectiveness of three-dimensional visualisation on undergraduate nursing and midwifery students' knowledge and achievement in pharmacology: a mixed methods study. *Nurse Educ Today.* 2019;81:19–25. doi: [10.1016/j.nedt.2019.06.008](https://doi.org/10.1016/j.nedt.2019.06.008)
- [41] Howell JN, Conatser RR, Williams RL, et al. The virtual haptic back: a simulation for training in palpatory diagnosis. *BMC Med Educ.* 2008;8(1):1–8. doi: [10.1186/1472-6920-8-14](https://doi.org/10.1186/1472-6920-8-14)
- [42] Allcoat D, von Mühlengen A. Learning in virtual reality: effects on performance, emotion and engagement. *Res Learn Technol.* 2018;26. doi: [10.25304/rlt.v26.2140](https://doi.org/10.25304/rlt.v26.2140)
- [43] Kavanagh S, Luxton-Reilly A, Wuensche B, et al. A systematic review of virtual reality in education. *Themes Sci Technol Educ.* 2017;10(2):85–119. In.
- [44] Youde A. “Face-to-face trumps everything”: an exploration of Tutor perceptions, beliefs and practice within blended learning environments. *Educ Sci.* 2020;10(5):147. doi: [10.3390/educsci10050147](https://doi.org/10.3390/educsci10050147)
- [45] Glegg SMN, Levac DE. Barriers, facilitators and interventions to support virtual reality implementation in rehabilitation: a scoping review. *PM&R.* 2018;10(11):1237–1251.e1231. doi: [10.1016/j.pmrj.2018.07.004](https://doi.org/10.1016/j.pmrj.2018.07.004)
- [46] Booth A, Hannes K, Harden A, et al. Coreq (Consolidated criteria for reporting qualitative studies). *Guidelines Report Health Res: User's Man.* 2014:214–226. doi: [10.1002/9781118715598.ch21](https://doi.org/10.1002/9781118715598.ch21)